HOOKWORM AND MALARIA RESEARCH IN MALAYA, JAVA, AND THE FIJI ISLANDS

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REPORT OF
UNCINARIASIS COMMISSION
TO THE ORIENT
1915–1917

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AUTHORS' NOTE

This volume represents an abridgment of the detailed report submitted by the undersigned as a result of their inquiries into the extent and importance of hookworm disease in Malaya, Java, and Fiji, and the comparative significance of this disease and malaria as disabling factors. Mr. Robert Goldsmith assisted in rewriting and condensing the voluminous data which comprised our original manuscript and arranged them in their present convenient form. The unabridged report is being preserved intact in the library of the Rockefeller Foundation, where persons who are interested may consult it.

2. Our work was intended to make no effort toward the control of either hookworm disease or malaria. Its purpose was merely investigative. The authors regret that in many cases they found it impossible to secure a satisfactory number of cases for their experiments. This difficulty applied particularly in the case of their studies of various drugs for use in treating hookworm disease. Many patients absconded during the rather prolonged periods it was necessary to keep them under observation and treatment. The reader will recognize the experiments in which the number of cases considered was perhaps too small for satisfactory conclusions to be drawn from them, and will understand that the results of the experiments are to be taken not as sufficient in themselves to establish facts, but as subject to confirmation by more extended investigation. To this end the number of cases considered in each experiment has been clearly indicated in each of our various tables and graphs.

3. It should be understood, further, that many of the experiments, more particularly those relating to the treatment of hookworm disease, were carried out in jails and hospitals. It may be that under less perfectly controlled conditions, such as those which obtain in the field, certain differences would have resulted in the findings, which in turn would have required certain modifications in our recommendations.

4. The authors desire to acknowledge their indebtedness to the medical and administrative officers of the countries visited, to the planters, and to the other officials and private citizens who placed their time and facilities so generously and unreservedly at the disposal of the Commission. Especial thanks are due Sir Arthur H. Young, K.C.M.G., Governor of the Straits Settlements and High Commissioner of the Federated Malay States; Sir Edward L. Brockman, K.C.M.G., Chief Secretary of the Federated Malay States; Dr. Charles Lane Sansom, C.M.G., Principal Medical Officer of the Federated Malay States; Dr. W. Gilmore Ellis, P.C.M.O., Straits Settlements; Dr. W. Th. deVogel, Hoofd Inspecteur Geneeskundigen Deinst in Nederlandsch Indie; and Dr. G. W. A. Lynch, P.M.O.,

Fiji, for the invaluable opportunities for investigation which they accorded the Commission.

5. A tabular summary of the findings of the Commission follows the regular text matter of the report. This summary consists of fifty-five separate tables, pages 120 to 178. The more important facts presented in the tables have been arranged in graphic form, and the graphs have been placed as close as possible to the text which discusses the facts they exhibit. There is a separate graph for practically every table. The text matter, in addition to being accompanied by the graphs which relate to it, contains reference to the supporting tables, and the graphs and tables in their turn have been given proper cross references. This system will aid the reader to locate at once all facts bearing on any particular subject, whether the facts be in graphic, text, or tabular form.

S. T. Darling
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Fig 1.—Map of Federated Malay States

CHAPTER I

POPULATION AND LIVING CONDITIONS

Before the work of the Uncinariasis Commission to the Orient is reviewed in detail, the chief features of the countries visited will be briefly discussed, and some of the characteristics of their people will be mentioned.

I. THE FEDERATED MALAY STATES

The Malay Peninsula is situated in the most southeasterly portion of Asia and extends from the Isthmus of Kra to Cape Romania, a distance of 750 miles in latitude 1.5° to 6° N. Its width varies from 60 to 200 miles, and the total area of the Peninsula is 70,000 square miles. The area of the Federated Malay States alone is more than 25,000 square miles.

Topography of the Country. A mountain range of granite and limestone constitutes the backbone of the Peninsula. Certain peaks in this range reach a height of 8,000 feet. The largest alluvial tin deposits in the world are situated at the foot of the western slope of these mountains. The coastal plains on both sides of the mountain range extend from five to thirty miles; the eastern plain, which reaches to the China Sea, is the wider of the two. Many mangrove swamps are to be found on the western coast, which terminates at the Straits of Malacca.

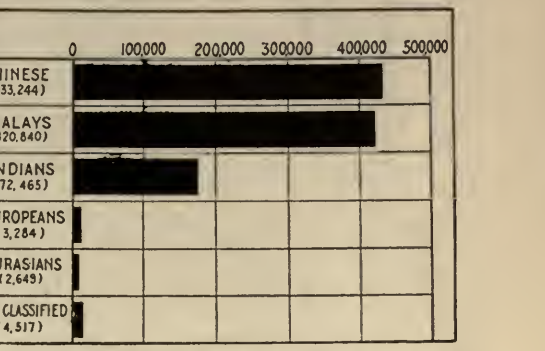

Fig. 2.—Population of Federated Malay States. By race. Census 1911. (Table 1)

Climate of Malaya. The climate of Malaya is tropical but it is less oppressive than that of Panama, for example, because the porosity of the soil prevents the air from acquiring the highest possible degree of saturation. Although the days are hot, the nights are usually cool. There are no prolonged periods of drought or rain, but there are between 150 and 200 rainy days each year, with a total annual rainfall ranging from 75 to 150 inches.

Population of Malaya. The work of the Commission in the Peninsula was confined to the Federated States and the Straits Settlements. The population of these states in 1911, according to census returns, was 1,036,999. (See Tables 1 and 2, pages 120 and 121.) Of this number about 725,000 were males and about 312,000 females, with great disparity of the sexes among the Chinese. All native adult females live either in marriage or in concubinage. It is an interesting fact that nearly four-fifths of all the people dwell in rural districts. With respect to religion, when the last census was taken it was found that of the total population there were about 400,000 Mohammedans, some 136,000 Hindus, approximately 7,000 Sikhs, and about 23,000 Christians. Ancestral worship was practiced by nearly all the Chinese, who numbered more than 350,000.

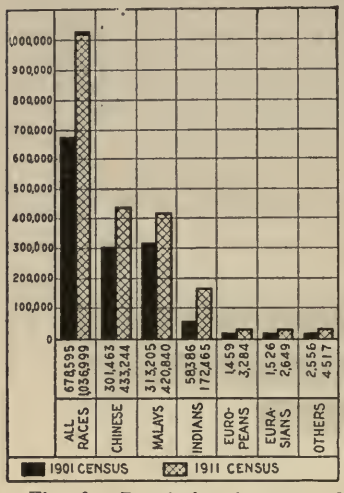

Fig. 3.—Population increase of Federated Malay States, 1901–1911. By race. (Table 2)

Character of the Native Malay. The native Malay is, as a rule, very superstitious. He believes, for instance, that Hantu, or evil spirits who live in trees, lurk about the house at night and exert a malignant influence on his family, his animals, his crops, and himself. It must not, however, be inferred from this that all Malays are devoid of intelligence. On the contrary, any one who has had experience in teaching these people is enthusiastic about their mental ability. While it is a common opinion that all Malays are indifferent and indolent, this is not the case except in the Federated States, where the natives' wants are few and where it is possible for them to supply these wants by merely a modicum of labor. In Java, where the population is more dense and where there is consequently a real struggle for existence, the Malays are both alert and industrious.

It is therefore proper to assume, with reference to permanent disease control measures, that both men and women would not be averse to receiving instruction in hygiene. But it is not highly probable that the Malays of the Federated States would be likely to inaugurate, or even to co-operate in bringing about, sanitary reforms which require concentrated and persistent effort. There is great lack of initiative. It may be that intermarriage and concubinage

of Malay women with men of the more virile races—particularly the Chinese—will in the course of time have the effect of altering somewhat the present listless character of the native.

Character of the Tamil Coolie. Most of the Tamil coolies in the Federated States come from the Madras Presidency in southern India, and are in the main ignorant, superstitious, and servile. Probably not more than 5 per cent of them are able to write their names. While it is true that Tamils are hard workers, it is also true that they are almost entirely lacking in ambition. Docile, unstable, and apparently quite incapable of administering their own affairs with either dispatch or intelligence, they constitute the white man's burden. But for the best interests of society they should not be permitted to exclude themselves from the civilizing influence of education; in their case there is marked need for instruction along the lines of sanitation. Their disinclination, for instance, to use the latrines provided by the Government or by the estates on which they are employed, is a direct menace to the community and, it is not too much to say, an indirect menace to the world. There is no doubt that the natives carry with them large numbers of hookworms, and, as a result of insanitary habits, dispense them throughout the communities in which they settle.

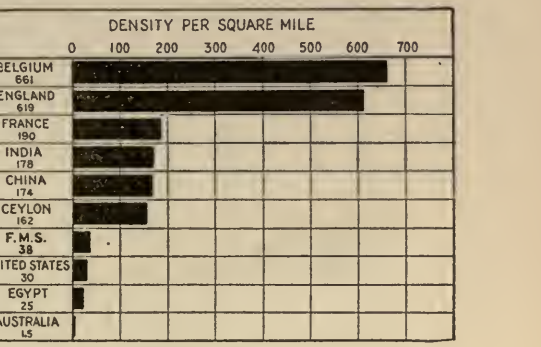

Fig. 4.—Density of population, Federated Malay States, compared with other countries. (Table 3)

Character of the Chinese Coolie. The residence of the Chinese coolies in the Federated Malay States is usually transitory. A few may plan to remain permanently, but for the most part it is the intention of these migratory people to work and save for a comparatively brief period, and then return to China.

The *materia medica* of the coolie is medieval. Even hospital attendants have been known to eat dog, really believing it to be an efficacious remedy for certain prevalent diseases. Such ignorance, however, must not be taken to mean that the coolies are altogether indifferent to the importance of education. The fact is that they are not averse to general instruction with respect to both personal hygiene and sanitary reform. But probably because of their extraordinary racial obstinacy it is extremely difficult to convince the coolies,

by argument, of the urgent need of actually doing their part in effecting such reform.

The principal diet of these people is boiled rice with some pork, fowl, or fish, and a number of vegetable and "paste" dishes highly seasoned with chilies. All except Straits-born Chinese use chopsticks. The Chinese eat more generously than the Tamils.

Chinese coolies bear the brunt of the hard work that is done in Malaya. In round numbers, approximately 150,000 are engaged in mining, 65,000 in agricultural pursuits, 10,000 as woodcutters, and 7,000 as rickshaw pullers. Chinese on rubber estates receive higher wages than Tamils. One reason is that they are more efficient workers; another is that they suffer less from malaria infection, and for that reason are less expensive to keep in good physical condition. Tamils receive from 30 to 40 cents a day, in Straits currency. (One dollar in Straits currency equals about 55 cents in United States money.) Chinese tappers, however, are frequently paid as much as 50 cents a day. Between wages and hemoglobin content there is a marked parallel which is more than a mere coincidence. In other words, the better physical stamina of the Chinese, as contrasted with the Tamil, means higher wages for the former.

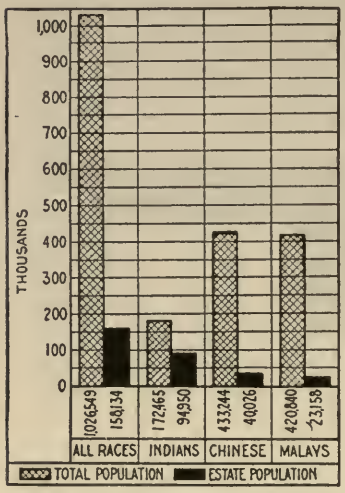

Fig. 5.—Population of Federated Malay States living on estates. By race. (Table 4)

Education in Malaya. In 1912 there were 373 vernacular schools in Malaya—one in almost every village. All of these schools were either under direct government control or aided by government grants. There were, in addition, a few Tamil and a few Chinese schools situated where the Tamil and Chinese populations, respectively, were particularly numerous.

Principal Industries of Malaya. The principal industries of Malaya are mining and agriculture. In 1912 a little over 280,000 acres were leased for mining purposes; more than 26,000 acres were actually occupied; the value of the products amounted to more than $84,000,000; and over 160,000 persons were engaged in one or another mining industry, tin ore being the chief mining product. Many alluvial fields are both owned and worked by Chinese. For

a considerable period coffee was the principal product raised on the estates, or plantations, but in recent years planters have been growing rubber in preference, because it is so much more profitable. Cocoanuts and rice are also grown; in the year 1912 over 150,000 acres were devoted to the former. (See Tables 4 and 5, pages 123 and 124.)

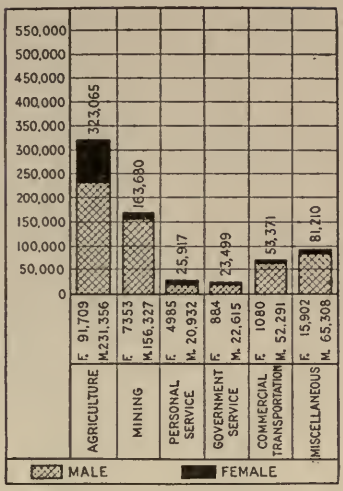

Fig. 6.—Population of Federated Malay States engaged in principal occupations. Male and female. (Table 5)

Government of Malaya. Inasmuch as it is a fixed policy of the Rockefeller Foundation International Health Board always to work in the closest possible co-operation with the Government in the countries where it is laboring, a few words will be said about the history and the government of Malaya.

Since the conclusion of the Panghor Treaty in 1874, the Federated Malay States—Perak, Selangor, Negri Sembilan, and Pahang—have really been under British protection, although federation was not actually brought about until 1895—twenty years after the treaty had been concluded. The non-federated states and Johore, although nominally independent, are also within the British sphere of influence.

Thanks to the British occupation, the territory has been opened to agriculture, and good transportation facilities have been provided. The tin-mining industry has been so thoroughly developed, and has proved so successful, that it has yielded an annual revenue large enough to provide for many public works.

Public Health Work in Malaya. Among the more important activities of any country are those that pertain to the health of the people. Public health work in the Federated States is fairly well established. There are a Principal Medical Officer at Kuala Lumpur, a Senior Health Officer in each of the four states, and a District Health Officer in each of the several districts within each state. In addition, there are a director for the Institute of Medical Research, a pathologist, a bacteriologist, a chemist, and two health officers in each state. The health work is so organized that general and district hospitals serve as centers. Fourteen of these are provided and maintained by the British Government, and fifty-two by the Government of the Federated Malay States. There is also a

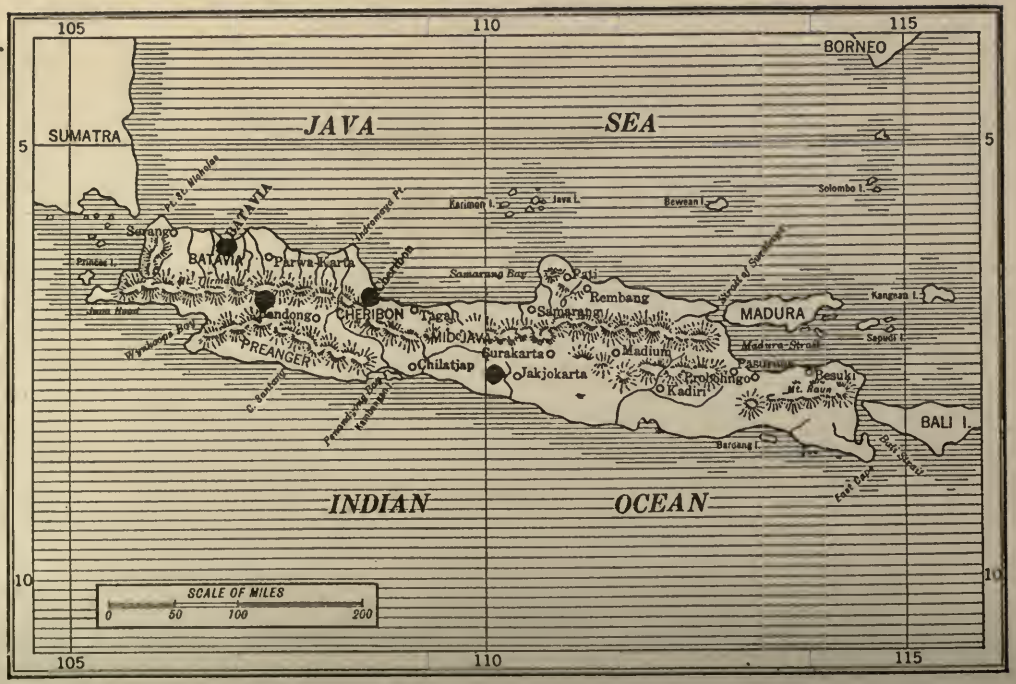

Fig. 7.—Map of Java

Black spots indicate where investigations have been conducted

Malaria Board and a Nursing Association. As for sanitary conditions, the water supply is good and the coolies on the estates are provided with proper conveniences.

II. THE ISLAND OF JAVA

The Territory and the People. In order that the findings of the Commission might be made more generally applicable throughout the Orient, the scope of the investigation was extended to include the islands of Java and Sumatra. In the urban communities of Java the native people live in kampongs, or collections of houses with fenced-in gardens shaded by cocoanut, sugar-palm, and fruit trees, and often inclosed by those city streets occupied by the shops, offices, or residences of Europeans. In the rural communities the people live in dessas, or native villages which accommodate from 300 to 3,000 persons. These dessas are surrounded by rice sawahs and cane fields.

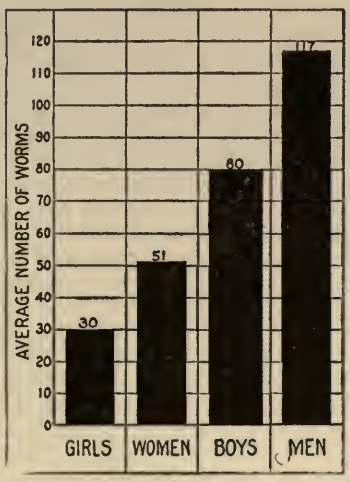

Fig. 8.—Relation between length of time spent in infected sawahs, or rice fields, and number of hookworms harbored. By sex and age groups. Java

The unhygienic habits of the people, and the lack of sanitary conveniences, in both urban and rural communities, are such as to be a constant menace to public health. A large proportion of the men, women, and children make a practice of defecating in the drains, ditches, and canals, near public market places, beside railroads, along country lanes, and in rivers and irrigation channels. Not infrequently they bathe their bodies and wash their rice in the same streams.

III. THE FIJI ARCHIPELAGO

General. For the purpose of checking up the findings of the Commission in the Federated Malay States, in Java, and in Sumatra, two members of the Commission spent three months in the Fiji Islands and there conducted extensive inquiries.

The low spleen rate of Tamils entering the Malay States at Port Swettenham from South India led to the belief that it would be possible to find in some parts of the tropics districts free from malaria, for although hookworm disease is practically universal in the tropics, malaria is not co-extensive with it. Indeed, it is known that Barbados and many of the islands of the Pacific—including the islands of the Fiji Archipelago—are entirely free from malaria. The fact that the studies of the Commission in the Federated Malay States had been very largely concerned with the effect of malaria and hookworm infection upon Indians, taken in connection with the fact that there were in the Fiji Islands a large number of free and indentured Indians who had lived there for from six months to thirty years, convinced the Commission that Fiji would serve admirably for purposes of control experiments. The island of Viti Levu, the largest island in the group, was selected as the field for intensive study.

Climate of Fiji. The climate of Fiji is tropical but very healthful, for, although the heat of the sun is intense, it is tempered during the day by cool breezes from the south and east. At night it is frequently necessary to use a blanket. The heat is never so enervating there as in either Malaya or Java. Natives, both men and women, are of large stature and of great physical endurance. Their vigorous condition is certainly due, at least in part, to freedom from malaria. Moreover, the Indians of Fiji also seemed to be in better physical condition than those examined in Malaya. The Commission did not find it possible to determine scientifically whether this was properly attributable to the more bracing climate of Fiji, or to the fact of their North Indian origin.

Character of the Native Fijian. The native Fijian is not disposed to engage in sustained, monotonous labor, except to attend to the cultivation of his own taro beds in the village. This indisposition may be due to either custom or temperament, or it may be due to the fact that he is a land-owner and does not feel the necessity of exerting himself continually. However, he is always able and willing to do work that requires the exercise of great strength spasmodically, as in the case of the boatman, the drayman, or the housebuilder.

Indian Coolies in the Fiji Islands. The Indians in Fiji come from Calcutta and from the Madras Presidency. Their term of agreement is five years, and their wages are fixed by the Indian Government. During the period of their indenture they receive free medical attention in the plantation hospitals, which are in charge of European physicians. The value of this attention becomes evident from a comparison of their condition with that of free or unindentured coolies, who have no such privilege of free medical treatment. The Government requires good latrine accommodations, and careful inspections are made by medical authorities to see that

Fig. 9.—In the great struggle for subsistence in the beautiful island of Java, men and women become beasts of burden but are not brutalized in the process

Fig. 10.—The hill sawahs of Java. Rice and potatoes are cultivated here. Hookworm infection was light

Fig. 11.—One of the canals of old Batavia, Java. Here the people bathe, urinate, defecate, and wash their clothing and rice. Hookworm incidence, 95.2%; average number of worms, 49

Fig. 12.—Food being sold from the ground. One means of spreading worm infection

sanitary regulations are complied with. Although at the expiration of their term of indenture, these Indians may re-engage for an extended period, they seem to prefer to acquire small holdings of from eight to ten acres and to settle on the land as farmers; or else they choose to go into business in a small way, as shopkeepers. Very few ever return to India, although continuous residence in Fiji for a period of ten years entitles them to free return transportation. The reason for their preference is evidently that in Fiji they enjoy greater prosperity than they do in their native country.

This review of the lands visited and of the people studied is of course not exhaustive. It merely represents an attempt to provide a general background for the more detailed description of the Commission's labors which is to be given in ensuing chapters.

CHAPTER II

ORIGIN OF THE INVESTIGATION

Preliminary Inspection. Early in 1914 the General Director of the Rockefeller Foundation International Health Board made a tour through the Orient. His object was to observe conditions and gather data regarding the customs and habits of the people and the relation of these customs and habits to their general health and working efficiency. The itinerary included Egypt, Ceylon, the Philippine Islands, and the Federated Malay States. Opportunities were afforded in Malaya to study conditions from Penang to Singapore, and data especially prepared in advance were made available for inspection. A number of rubber and cocoanut estates were visited, and some 2,000 coolies were clinically examined. There were indications on every hand of the universal prevalence of hookworm disease, as well as of malaria.

Need for the Investigation. Considerable uncertainty was found to exist among the planters and physicians interviewed, in regard to the seriousness of hookworm disease as a menace to health and as a detriment to efficiency. While the limited amount of reliable data available pointed to malaria as the principal disabling disease on the estates, there was also much convincing evidence that on a number of these plantations hookworm infection increases and severe anemia results.

The anemia which results from malaria cannot be distinguished from the anemia which is due to hookworm disease. The two diseases are in fact so complicated that the value of unverified conclusions is rendered extremely dubious. In view of this large element of doubt, it was felt that in advance of any recommendation of expenditures for the relief and control of hookworm disease, there was real need for a scientific investigation by an independent commission, fully supplied with the necessary funds and equipment.

Medical men were in agreement as to both the possibility of determining the relative importance of hookworm infection as a disease-producing entity, and the desirability of settling this question before any considerable amount of work for immediate relief and ultimate control should be undertaken.

Appointment of Uncinariasis Commission. The local representatives of the British Government were approached with reference to their attitude concerning the appointment of a commission of inquiry. It developed that the Government was not only friendly, but cordially sympathetic. As a result, it was agreed in conference at Government House, Singapore, that the first effort should be directed toward ascertaining the facts. The appointment of a com-

Fig. 13.—Laboratory of Uncinariasis Commission to the Orient, located at Kuala Lumpur, Federated Malay States

Fig. 14.—Interior of field laboratory, used by the Commission in Java. The laboratory was placed beside a great cement open drain on one of the streets of the kampong. Huge floating fecal masses, so characteristic of rice-eaters, came floating down the drain. Cholera is usually present in this kampong

Fig. 15.—Scene in Batavia. Here throngs of people come to wash their clothes and rice and to bathe in the sewage-polluted stream

petent commission of scientific investigators was authorized by the Board, and Dr. Samuel T. Darling, Dr. Marshall A. Barber, and Dr. H. P. Hacker were selected. Dr. Darling was made Chairman of the Commission and instructed to conduct studies in such places and in such manner as might be deemed expedient. Authorization was also given to employ the necessary clerks and technical assistants.

Task of the Commission. A memorandum of instructions was prepared for the guidance of the Commission in the conduct of its investigations. As defined in this memorandum, the purpose and object of the Commission was "to determine to what degree Uncinaria infection is a menace to the health and working efficiency of the people in the country under consideration." The intimate relation found to exist between malaria and hookworm disease as disabling factors made it necessary for the Commission to devote almost as much time and study to malaria as to hookworm disease, in order to determine the relative importance of the two infections as causes of anemia. The Commission came to be known as the Uncinariasis Commission to the Orient.

CHAPTER III

EXTENT OF THE INVESTIGATION

The Commission assembled at Kuala Lumpur on June 2, 1915, and there, in the District Hospital, established permanent headquarters. There were 465 beds in this hospital; the daily number of sick averaged 334; the total admissions for the year 1915 amounted to 4,868. Most of the patients were suffering from dysentery, malaria, beriberi, ancylostomiasis, or tuberculosis. From these facts it will be evident that the Commission found plentiful material available for study. Much valuable and necessary work was done in the laboratory here, by way of training assistants and developing technical skill. They were given opportunity to study cases of anemia and to learn methods of treatment.

For a month after arriving at Kuala Lumpur, the members of the Commission made a tour of the vicinity in order to familiarize themselves with the new situation. It became evident at once that there was much malaria, everywhere and among all classes, and moreover that this disease was responsible for an enormous amount of acute and chronic disability. Malaria surveys were made in a number of neighboring localities, in the course of which anophelines were dissected to determine the presence of malaria plasmodia, and the spleen and parasite rates of patients were taken and recorded.

Plan of Action. The Commission pursued the following plan in conducting its inquiry:

(1) It studied by clinical and laboratory methods the cause of anemia among the patients who were admitted to a large general hospital.

(2) It examined at the detention camps at Port Swettenham and Singapore a large number of Tamil and Chinese immigrant coolies from southern India and southern China. At Port Swettenham 2,261 Tamil coolies were examined and at Singapore 700 Chinese coolies.

(3) It treated with chenopodium, or some other vermicide, a considerable proportion of those who on examination showed evidence of hookworm infection. Of the 2,261 Tamils examined at Port Swettenham, 35 were treated individually, and 391 in groups of 40. Of the 391 treated in groups, 308 received two treatments of chenopodium, and 83 two treatments of thymol.

(4) It made every effort to trace the treated cases to the several estates and mines where they worked. This was for the purpose of re-examining them in order to determine the effect of residence in the Federated Malay States (and consequent exposure to hookworm infection and malaria) on their general health and working efficiency; and at the same time to estimate the relative effect of the two diseases in causing anemia, and to determine the value of treatment.

Fig. 16.—Group of night-soil coolies in the Federated Malay States. The hemoglobins of the men, from left to right, were 47, 65, 80, 85, and 92, respectively, or 74 average; the numbers of hookworms harbored were, respectively, 676, 562, 256, 280, and 649, or 485 average. The blood of all five was negative to malaria plasmodia. The spleens of the third and fourth men were enlarged; those of the other three were normal. The condition of these coolies is often good because, being pariahs, they suffer no dietary restrictions

Fig. 17.—Malay boys' school, Kampong Bharu, Kuala Lumpur. Forty-two boys were treated here. They remained away from their homes, taking their meals and sleeping in the school house for four days. Showing how amenable to discipline are these sons of "the mildest men that ever scuttled a ship or cut a throat"

Work at Port Swettenham. All incoming Tamil coolies were detained at the quarantine camp at Port Swettenham for a period of one week. Nearly all of the Tamils examined (for plasmodia in the blood, and for ova in the stools) were found to be in a fair condition of health, and remarkably free from ulcers and other skin diseases. Arrangements at the camp were very convenient for the investigations undertaken. Twelve inclosures were arranged in a circle around a central administrative building, and were so constructed as to be quite independent of one another. Each had its own water supply and its own water-flushed latrines, with proper drainage system. A common kitchen was situated in the central open space. Thanks to the generous co-operation of the authorities, one of the buildings was temporarily converted into a laboratory with adequate facilities; also an excellent ward in the camp hospital was made available for the use of the Commission.

As an aid to future identification, a history of each coolie was taken. A record was kept of his father's name, his own name, his age, his caste, his personal characteristics, and the village of his origin. A spot map was made not only showing this place of origin, but also giving the following data: anemic cases; whether or not the coolie was found negative to hookworm infection after three examinations; enlarged spleens; and enlarged spleens in relation to anemia. The name or number of the estate to which each coolie was going was placed on a disc provided by the immigration authorities. If at any time previously the coolie had ever left India for any other country, he was rejected for the purposes of this investigation. The cases chosen for treatment were all scheduled to go to estates that had selected twenty or more, a number sufficiently large to justify the Commission in paying a visit to those particular estates.

Work on Estates. After an interval of from 30 to 42 weeks the coolies who had been examined at the ports of entry—or as many of them as could be traced—were followed to the several estates to which they had gone to work. Fourteen estates were thus visited, and 264 coolies were identified and re-examined for signs of anemia, malaria, and hookworm disease. Statistics were tabulated with reference to both those who had, and those who had not, been treated for hookworm infection at Port Swettenham, and who, subsequently (on the estate) either did or did not show signs of malaria. This work of investigation on the estates was begun about the middle of June, 1916, and was concluded about the end of August, 1916, a period of approximately two and one-half months.

The re-examination, on the estates, of cases treated at Port Swettenham showed that the benefit of treatment for hookworm disease was nullified on the flatlands estates, as a result of re-infection, but that on the hilly estates the beneficial results of treatment were maintained, provided the coolies did not contract malaria. This disease was found to be the chief anemia-producing factor on these latter estates, while hookworm infection was found to be relatively

unimportant. The contrary proved to be true on the estates located on flat coastal plains.

Work among School Children, Mine Laborers, and Others. In addition to the work of investigation carried on among coolies at detention camps and on estates, the Commission conducted a number of special studies in the Federated Malay States among children in schools, laborers in mines, patients in hospitals, inmates of prisons, and night-soil coolies.

Fifty-eight children were treated at the Convent School at Kuala Lumpur. These children lived under fairly constant conditions, were well nourished, received good care, and in their surroundings were comparatively free from exposure to malaria or hookworm infection. They were only lightly infected with the latter. No definite relationship was established between the duration of residence and the number of worms harbored.

Two Malay schools for boys and one for girls were visited and the children examined—83 boys and 40 girls. Two of the three schools, one for boys and one for girls, were located at Kampong Bharu, a suburb of Kuala Lumpur. The surroundings of these schools rather favored malaria and, as there was not a little pollution of the soil, there were plenty of opportunities for direct exposure to hookworm infection. There was evidence of association between worm-count and hemoglobin content whenever the number of worms harbored was above 150.

Work among Night-Soil Coolies. For purposes of comparative study, 35 coolies employed on the public roads of Kuala Lumpur and 90 coolies engaged in collecting, transporting, and burying night soil were examined. Most of these laborers, particularly those in the latter group, belonged to the pariah class of Tamils. Both groups were infected with malaria and hookworm disease. Naturally, the night-soil coolies were directly exposed to hookworm infection, and examination showed that they had a high incidence of Necators, as well as a high incidence of Ancylostomes derived from the feces of Chinese. Duration of exposure to infection—that is, the length of the period during which the laborers were employed at this kind of work —bore a direct relation to the number of Ancylostomes harbored.

Work among Laborers in a Tin Mine. The Commission visited a tin mine and examined two hundred workers in an attempt to discover the degree of hookworm infection present, and to determine its effect on the efficiency of the Chinese laborers employed in both surface and underground workings. It was not easy to get at the facts. The mine was operated by laborers under a contract which left them free to work as much or as little as they pleased. At the end of each shift they were paid by a headman for whatever they had done. Under these circumstances there was very little co-operation.

Regarding the data obtained, anemia was not found to be present in any marked degree. The general condition of the workers was

good; the ulcers which many of them had were probably occupational in origin. A comparison of these mine workers with a group of coolie prisoners in Taiping Jail showed that there were some in the jail who had lower hemoglobins than those who worked in the mine. Probably the explanation is that the less efficient are eliminated from the mines, while both the more efficient and the less efficient are to be found in the jail. Comparative tests indicated that the average hemoglobin percentage among underground workers was slightly less than among the surface workers. Examination of the stools showed a slightly higher percentage of hookworm infection among the former than among the latter. There were very few cases of either malaria or dysentery, but all such cases showed a lower hemoglobin average as a result.

Work among Prisoners and Patients. At Taiping Jail, 393 prisoners were clinically examined during the month of August, 1916, and 354 were chosen for treatment. Dysentery was found to be a decided factor in producing anemia. There was no opportunity for hookworm infection either in the prison or by means of the latrines connected with the prison.

At the District Hospital at Kuala Lumpur, a charitable institution, 588 patients were examined for plasmodia in the blood, and 524 for ova in the stools. Special groups of Europeans, Eurasians, Sikhs, Chinese, Japanese, and Tamil men and women were treated here and at the General and European Hospitals. At the Victoria Institution, a school for boys, 500 students were examined.

Control Investigation in Java and the Fiji Islands. Besides these visits made by the Commission to a number of places in several different localities of the Federated Malay States, one member of the Commission spent a month on the island of Sumatra investigating methods of treating hookworm disease. Afterward, this same member visited the island of Java, and for four months studied hookworm infection both with and without malarial complications, among the natives in urban as well as rural sections. Then, for the purpose of checking up the findings of the Commission in Java, Sumatra, and the Federated Malay States, two members visited an island in the Fiji Archipelago (Viti Levu) known to be entirely free from malaria.

In the course of its investigations the Commission microscopically examined the feces of 3,776 Tamils, Chinese, Malays, Bengalese, Singalese, and Eurasians, and found that of this number 87.8 per cent were positive for hookworm ova. (See Table 6, page 125.) The labors of the Commission extended over a period of twenty-five months.

CHAPTER IV

METHODS OF EXAMINATION

Two Principal Methods. The actual presence of hookworms in a person suspected to be infected may be determined either by microscopic examination of the feces for ova (smear and centrifuge methods), or by vermicidal treatment and the recovery of worms expelled. The latter is the more accurate method. The present chapter will be devoted to an exposition of these methods of examination for determining infection; in the next chapter the technique of treatment, as tested by experience, will be discussed in detail.

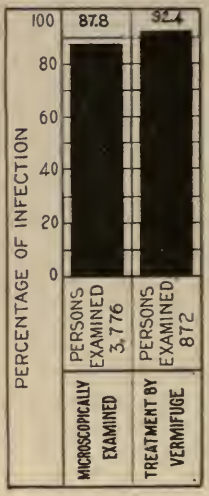

Fig. 18.—Respective merits of microscopic examination and medication as means of revealing hookworm infection. All races. (Table 6)

EXAMINATION OF FECES FOR OVA

Smear Method. There are two methods of examining feces for hookworm ova—the smear method, and the centrifuge method. The smear method as described below was used most often in the course of the Commission's investigations because, owing to its simplicity, it enables the microscopist to make, with the least expenditure of time, an estimate of the number of ova in each specimen.

Microscope slides (2″ x 3″) are prepared in advance. Each slide is labeled so as to correspond with the number given to the particular specimen under examination. An area is inclosed on the upper surface of the slide by means of a line drawn with a grease pencil. A mixture of glycerine and saturated solution of NaCl, in equal parts, is dropped into this area along with a portion of feces which has been diluted with water and thoroughly stirred, to insure a fairly uniform distribution of the ova throughout the mass. Experience showed that the best results are to be obtained when the amount of feces is so large as almost to overflow the greased lines, and yet not so large as to be too opaque for microscopic examination.

Fig. 19.—Night-soil disposal. The buckets containing feces are brought to the burial place in bullock carts. Note the children (three) who daily accompany their parents. These coolies harbor six times as many *A. duodenale* as the road coolies, the worms being derived from the feces of the Chinese residents of Kuala Lumpur

Fig. 20.—Night-soil disposal. Filling the trenches. Surface contaminated with feces, and one has to walk with the greatest circumspection. A guard is placed nightly to prevent the Chinese market gardeners from exhuming the buried night soil. The efforts of the guard are, as a rule, futile

Fig. 21.—Night-soil disposal. Washing the buckets. The shore is heavily polluted. Hookworm larvae were detected here

Ten or twelve of these slides, prepared by especially trained dressers, are then placed on a slide-holder constructed of a thin board, and brought to an expert microscopist for examination. The actual examination of ova was never intrusted to a subordinate. Because of the difference in specific gravity the worm ova always rise to the surface; then they are readily recognized. The action of the glycerine in clearing the fecal mixture more rapidly than it does the worm ova, makes the ova especially conspicuous.

Centrifuge Method. The centrifuge method and a modification of the centrifuge method are both used. As in the case of the smear method, the centrifuge process involves, first, mixing a mass of fecal matter with water, according to consistency. The mixture is then placed in a test tube and centrifuged, after which the supernatant fluid is poured off. A saturated solution of NaCl is added; or, if glycerine is available, a mixture of equal parts of glycerine and a saturated solution of NaCl is added and thoroughly mixed. Then the mass is again centrifuged. Enough liquid is added to practically fill the tube. The ova are removed by means of wisps of cotton, which are mounted and examined under a microscope.

A modification of this method of removing the ova—which was also used—is the following. Wisps of cotton, with one end twisted into a tail, or pieces of cotton string frayed at one end, are prepared in advance. When one of these is placed in the test tube the frayed portion floats to the surface of the fluid. Two or three drops of a 2 per cent solution of ordinary nutrient agar are then dropped into the tube. It is better to do this when the melted agar is still hot. If glycerine is not available, saturated solution of NaCl will answer. The agar will float and solidify as a disc, and the ova, rising, will adhere to this disc.

When the tubes, thus prepared and labeled, are placed in a rack and brought to the microscopist, the agar disc is lifted off without difficulty by means of the twisted end of the cotton wisp. The disc is then placed on a slide, fecal surface uppermost. A cover glass is adjusted and pressed down, and the preparation is ready for examination. Two discs may be placed on one slide. It will not be found difficult to detect the ova, for if they are not found on the surface of the disc they will be found but very slightly imbedded. It is better to examine these preparations before the ova have had an opportunity to become transparent—say within an hour—for in a condition of transparency they are more difficult to detect.

In populations in which there is a large percentage of persons positive to hookworm, this method offers the advantage that as many as thirty cases an hour can be examined. When a specimen is found negative upon examination, further specimens can of course be obtained on subsequent days, for purposes of re-examination. But in a population heavily infected, such re-examinations of apparent negatives are not worth while. For example, of the 2,262 cases examined by the Commission at Port Swettenham, 64 who were

apparently negative were re-examined; but the results of these examinations were so slight as to raise the total positive by only 1.5 per cent. In one of the jail series, 349 cases were examined and 73 found to be apparently negative; but upon re-examination on subsequent days, only 11 of the 73 proved positive.

The reliability of feces examinations for ova can best be determined by comparing the percentage of positives thus obtained with the percentage obtained by recovering the worms expelled by treatment. In the work of the Commission the results secured by the two kinds of examinations were not strictly comparable. For instance, in some cases dealt with, the group examined for ova was not treated at all; in others, the treated cases had not previously been examined for ova. The feces examination usually included all cases which could be obtained, irrespective of the degree of anemia; in the treatment cases a larger percentage of infected persons than of non-infected were probably selected.

But in a general way the results from the two groups are comparable. The percentages of positives obtained by the two kinds of examinations are compared by races. (See Table 6, page 125.) The difference shown by the totals, 4.6 per cent, by no means fairly represents the superiority of the treatment method, because the different races show different rates of infection, and because the numbers examined by the two methods are unequal. Where a percentage of 80 was obtained by the method of examination for ova there is little doubt that a percentage of 90 or more would have been obtained by the method of treatment.

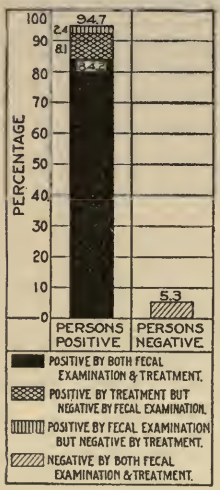

Fig. 22.—Relative accuracy of hookworm diagnosis by feces examination, as indicated by later recovery of worms; 209 cases treated irrespective of result of fecal examination. (Table 7)

A more exact comparison is obtained when the same individuals who are examined for ova are subsequently treated. In all, 209 cases were traced in which both sorts of examinations were made. The results of these examinations are shown in Table 7, page 126. Reference to this table will show that the method of feces examination failed in 8.1 per cent of cases in which it was later demonstrated that hookworms were present, and that ova were found in 2.4 per cent of cases in which treatment failed to detect any worms. Second specimens of stools were available for re-examination for ova in the case of only one of the 17 negatives. The species and number of hookworms found in these 17 cases are given in Table 8, page 127. It will be seen that 3 of the 17 cases showed no female worms at treatment, and that 12—or nearly three-

fourths—had two females or less. Apparently a single thorough examination of a stool fails only in the case of lighter infection.

Vermicidal Treatment and Recovery of Worms. The procedure followed in examination by the method of vermicidal treatment and recovery of worms expelled, was practically the same in all cases. The people were called together, physical and clinical examinations were made, and representative cases were selected on the basis of hemoglobin estimations. On the morning of the day previous to treatment patients were allowed their usual diet; in the afternoon they were given some rice gruel and a half-pint of milk. At 5:00 P.M. a purgative was given—six drams of saturated solution of magnesium sulphate, or one ounce of sodium sulphate, or one ounce of castor oil.

On the morning of treatment all food was generally withheld, although in some cases a little milk was permitted. The first dose of the vermicide was given at 7:00 A.M.; the second and third doses were given at hourly intervals thereafter. Two hours after the last dose of the vermicide a second purgative dose was administered, corresponding to the one given the night before. At 12:30 noon, the patients were allowed to drink milk, and in the afternoon they were given a little rice or bread. The next day they were allowed to have rice and curry, but vegetables with coarse fibres were prohibited because they interfered with the search for worms. If a patient remained constipated the purgative was repeated. Patients were enjoined to remain prostrate for a certain period after the administration of the vermicide.

When chenopodium in the pure state was given, it was administered in hard gelatine capsules, which were filled at the time from a standard pipette. When an emulsion of oil of chenopodium in acacia was given, it was prepared fresh on the morning of the treatment. The bottle was well shaken before each dose was given. Doses, measured with a measuring glass, were given and were followed by a drink of water. No separate purgative was required when the emulsion contained castor oil. Thymol also was frequently used in order to test the relative value of different vermicides. After the contents were finely ground and weighed, capsules holding individual doses were filled on the day previous to treatment.

Varying amounts of different kinds of medicament were given for a first treatment; then, after an interval of from seven to ten days, a second treatment was given—usually consisting of a full dose of chenopodium (3 x 1 mil).* The efficacy of the treatment was determined by noting the percentage of worms removed, careful search being made of four or more stools submitted by each case. This search for worms naturally proved to be a tedious and laborious process.

Identification of Specimens. At the time of examination a numbered metal disc was attached to the wrist of each patient. At the completion of the treatment he was given a vessel to which his

*One mil is equivalent to one thousandth part of a milliliter, i. e., one cubic centimeter.

name and register number were attached. It was always found preferable to use enameled or agate vessels. These receptacles were thoroughly washed and dried after each using.

Rigid military discipline was instituted, to avoid any possible mixing of the feces of different cases. In jails, where each person was confined to his own cell, it was comparatively easy to avoid confusion. In hospital wards the vessel was placed at the patient's bedside and defecation was supervised by a dresser, who was given instructions to prevent the use by any patient of a vessel not his own. The patients themselves were also given explicit instructions. They were drilled in remembering their numbers, and in taking their places in right numerical order for treatment and for changing of vessels. In the case of children this drilling was facilitated by schemes of rewards.

The possibility of error from mixing of stools was altogether eliminated in one series by the device of giving each patient, at the time of treatment, a dose of small glass beads. These beads differed in color and size, and only one sort was given to each patient. For three or four days patients continued to pass these beads, and since there was no mixing of the different kinds of beads in the stools it is safe to say that there was no mixing of feces. In the whole series of treatments the degree of error due to the mixing of feces of different persons must have been negligible.

The procedure followed was to have the feces brought to the place of examination twice daily, at about 7:00 A.M. and again at about 2:00 P.M. Each patient usually brought his own specimen. When the patients entered the laboratory, the numbers on their wrists and on the vessels were compared and checked, and a slip of paper with the same number was placed in the vessel with the feces. All patients then received clean vessels, properly numbered. A record was kept of persons who brought no stools, and an additional purge was given to them when it was considered necessary and desirable.

Washing of Stools. A regular routine was followed in the washing of stools. Those that were soft or fluid could be washed at once; those that were more compact had to be mixed with water and stirred until soft. When a tap was available, the washing was done in the sink beneath it. Usually, however, there was no water piped to the laboratory, and it was necessary to use a stream siphoned through a rubber hose from a large container placed several feet above the ground. The washing was then done by means of a jet of water played into a large brass wire sieve (with a mesh of 50 to an inch) into which the contents of the vessel had been poured.

In order not to force the worms through the meshes of the sieve, it was found advisable to use a stream of moderated force. The regulation of the stream was readily accomplished by means of a pinch-cock at the lower end of the hose. The operation was always closely supervised so as to prevent splashing and consequent loss of

Fig. 23.—Prisoners in Java jail. Treatment squad changing "jerries"

Fig. 24.—Dr. Darling making the hookworm survey in Batavia jail

Fig. 25.—Squad No. 3, Java jail. Spleen rate, nil; parasite rate, 21.8%; hookworm incidence, 95.8%; average number of worms, 54; average hemoglobin, 94.6%; malaria, mild

Fig. 26.—Squad No. 2, Java jail. Spleen rate, 70.8%; parasite rate, 12.5%; hookworm incidence, 100%; average number of worms, 139; average hemoglobin, 44.8%; malaria, severe

material. Care was also exercised to provide against worms adhering to the sieve and being carried from one stool to another. After this washing process, the worms, the remaining insoluble portion of the stool, and the labeled slip were all rinsed into the vessel bearing the number of the patient whose stool had been examined.

The washed stool was next distributed into photographic developing trays, a small portion into each tray. A dark brown tray was found to furnish the best background for the worms. These were then picked out with needles or forceps and placed in properly numbered petri dishes containing normal salt solution. Frequently the trays were examined and the worms removed by assistants; but a member of the Commission always made a re-examination, sometimes on both a dark and a light background. It was possible for one member of the Commission to inspect and check up the work of two or more assistants, of course provided the actual number of worms which had to be picked out was not too great.

The original numbered slip which served as a label was placed, number side up, under the cover of the petri dish. This paper slip remained in direct contact with the contents of the stool, from the time the vessels were first received up to the time of the final counting and recording of the worms; it proved very effective in preserving accuracy. At least four stools were collected from each person. But the number that had to be examined was usually greater than that, for the series of washings in any one case was never considered complete until two consecutive negatives had been obtained. It is always highly important to expel the last worms, because the proportions of different species and sexes vary according to the interval following treatment.

Finally, the excess salt solution was drained from the petri dishes; the worms were then killed by flooding these dishes with boiling alcohol (70 per cent). As Lane has pointed out, when scalded the worms become rigid and assume the shapes that are characteristic of the different species. Differentiation is thus rendered comparatively easy and the worms can be rapidly counted. The Commission kept careful records of the numbers and sexes of the different species expelled and recovered.

CHAPTER V

METHODS OF TREATMENT

Routine Treatment. The routine technique of treatment was, first, to give one treatment with the remedy which was to be tried, and then to give chenopodium in the subsequent treatments. The first treatment was called the trial treatment, and the second treatment was called the test treatment. Experience convinced the Commission that this second treatment should never be given until after the lapse of one full week. After the first, or trial, treatment the worms expelled were collected and counted.

One week or more after the second, or test, treatment the stools were examined for ova, and if they were still found to be positive other treatments were given until they proved negative. Next, the number of worms expelled was counted, and it then became possible to determine both the percentage of the worms removed by the first treatment and the number of cases actually cured.

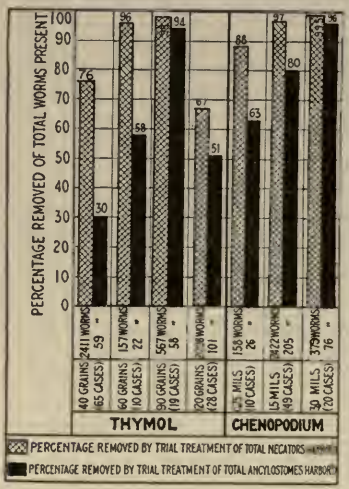

Fig. 27.—Comparative effect of thymol and chenopodium on two species of worms. (Table 9)

By way of preparation for treatment the patients in a certain series of experiments (at Taiping Jail) had their accustomed fare at 11:00 A.M., but at the afternoon meal—which was usually served at 3:00 P.M. —they were given only soft rice gruel. At 4:00 P.M. a concentrated solution of magnesium sulphate (one ounce of the salt) was given as a purge. On the following morning the patients had milk instead of their ordinary meal, and then the treatment was given. The last dose of medicine was followed, after an hour's interval, by a second purge of magnesium sulphate (one ounce). After the purge was given, the prisoners were again locked up in their cells, kept away from work, and allowed out only for exercise.

The stools were collected at 2:00 P.M. on the day of the treatment, and at 7:00 A.M. and 2:00 P.M. on the two days immediately following. These stools were washed and examined for worms until 72 hours had expired, and usually during this period six stools per

case were obtained. However, if at the end of 48 hours any patient had two consecutive stools with no worms in them he was released, always provided that at least four stools had been washed and examined. If at the time of any of the regular routine washings, a patient did not have a stool, he was immediately given another saline purge.

Relative Efficacy of Various Methods of Treatment. A considerable number of experiments (twenty-one separate series) in the administration of vermicides were conducted by the Commission, in the District Hospital at Kuala Lumpur and elsewhere. The particular object was to reach a scientific conclusion as to the quantitative value and relative merits and

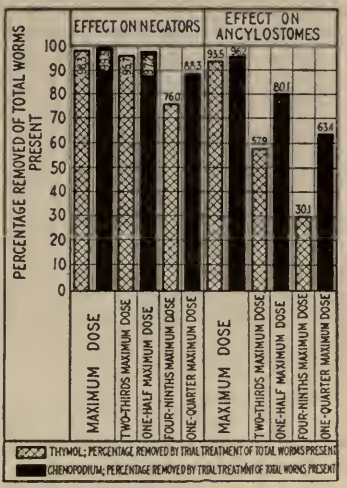

Fig. 28.—Effect of full and reduced dosages of thymol and oil of chenopodium in expelling two species of worms, trial treatment. (Table 10)

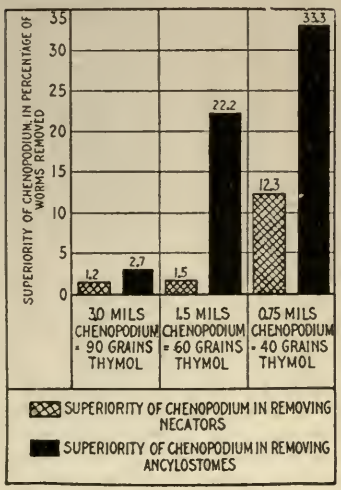

Fig. 29.—Superior efficacy of chenopodium, as compared to thymol, in removing more resistant worm species. (Table 11)

efficacy of differently graduated doses of chenopodium and thymol for routine treatment. The results of these numerous experiments can be summed up in a few paragraphs.

Chenopodium in small doses proved to be more efficacious than small doses of thymol; also it showed a satisfactory efficacy in a greater range of doses. While, dose for dose, both drugs showed about equal efficacy in removing Necators, chenopodium was quite superior to thymol in removing the more resistant species of hookworm, i. e., Ancylostomes. (See Table 9, page 128.) Chenopodium also was more effective in removing other worms, such as Ascaris and Trichuris. There was failure to cure the patient (by removing

all hookworms) in 23.6 per cent of the cases treated with thymol, but in only 7.6 per cent of the cases treated with chenopodium.

Better results are obtained from chenopodium when it is given in the original form of an oil than when it is prepared as an emulsion. On the other hand, better results are obtained from thymol when the drug is especially prepared in an emulsion than when it is administered in the form of a powder. The explanation is that chenopodium, a penetrating oil, on being received into the system is more uniformly distributed throughout the intestinal contents than is thymol when given as a relatively insoluble powder.

The half-maximum dose of chenopodium (.5 mil three times, or a total of 1.5 mils) is, in the experience of the Commission, the best treatment as a routine vermicide. For while it does not have the toxic effects of the full dose, it was found that it will in two treatments remove about 99 per cent of all the worms present. A single treatment of 3 mils of chenopodium gave the best results of any single treatment tried; but the 90-grain dose of thymol was only slightly inferior in results. Both effected very satisfactory removal of worms. In Tables 10 and 11, pages 129 and 130, are indicated the effects of varying dosages of these two drugs upon Necators and Ancylostomes.

Among the prisoners at Taiping Jail further experiments in treatment were conducted. Altogether 393 prisoners were treated, for the most part in groups of ten. In addition to the customary treatment with chenopodium (3 mils in 3 doses of 1 mil each) and thymol (90 grains in 3 doses of 30 grains each), a number of experiments were made with beta-naphthol (20 grains in capsules), with eucalyptus (30 minims), with chloroform (45 minims), and with castor oil (12 drams divided into 2 doses of 6 drams each). (See Table 12, page 131.)

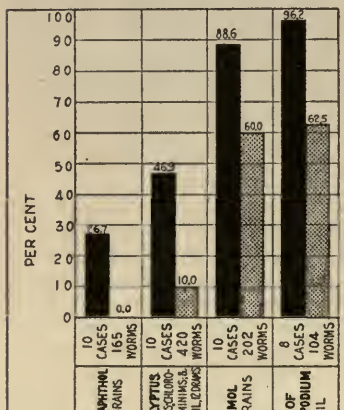

Fig. 30.—Efficacy of various vermicides in expelling hookworms and effecting cure. Worms removed by entire treatment; cases cured by trial treatment. (Table 12)

The cases of treatment were chosen at random. In the statistics no comparisons were made between Chinese, Tamils, and Malays, for the reason that Chinese harbor fewer worms than either Tamils or Malays, and for the further reason that they harbor a much larger percentage of Ancylostomes. Statistics with reference to the relative efficiency of different

drugs used in the treatment of the respective groups mentioned would be invalid because, as the Commission discovered in the course of its investigations, it is more difficult to obtain a high percentage of worms expelled when few worms are harbored than when the number of worms is great; moreover, Ancylostomes are much more tenacious than Necators, and hence more difficult to expel. The different races, it must be borne in mind, have different worm formulae.

The efficacy of chenopodium continued high even when the dose was reduced to one-quarter of the maximum dose; on the other hand, the diminution of the dose of thymol resulted in a

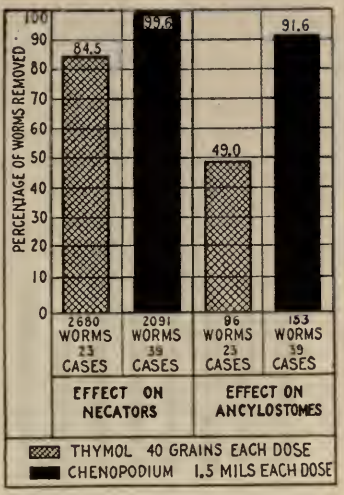

Fig. 31.—Hookworms expelled by two treatments of smaller than maximum doses of thymol and chenopodium. Two trial treatments. (Table 13)

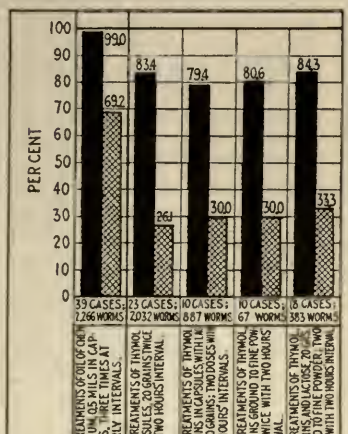

Fig. 32.—Worms expelled and cases cured by two half-maximum-dose treatments of chenopodium, as compared with two 20-grain treatments of thymol in various forms. (Table 14)

rapid falling off in efficacy. Two treatments of the half-maximum dose of chenopodium produced better results than one full maximum dose; in fact, the highest percentage of worms removed was obtained by this treatment—99.6 per cent of Necators, and 91.6 per cent of Ancylostomes. Two treatments with a small dose of thymol did not produce a good summation of results. Test votes taken clearly indicated that nearly all the patients preferred chenopodium to thymol, as being less unpleasant to take. For these several reasons, thymol was deemed less suitable for use in general treatments, and particularly in the treatment of children. (See Tables 13 and 14, pages 132 and 133.)

Another series of treatments (eight in number) was given in order to determine the action and results of eight different doses of chenopodium. All the patients were Chinese, and in all cases there was uniform preparation. These experiments showed that 3 mils of chenopodium in freshly prepared capsules, administered in doses of 1 mil, 3 times, at hourly intervals, gave by far the best results; 98.9 per cent of all the worms present were removed, and in 82.4 per cent of all the cases treated cures were effected. (See Tables 15 and 16, pages 134 and 135.)

The superior efficacy of freshly prepared hard gelatine capsules of chenopodium, as compared with the manufactured soft capsules, was demonstrated by two series of experiments. With one group of patients the manufactured capsules containing chenopodium were used, but with the result that only 66.4 per cent of the worms present were expelled. Then the chenopodium, extracted from manufactured capsules which have thick, tough gelatine walls, was placed in freshly prepared capsules. These were administered to another group, with the excellent result that 97.9 per cent of the worms present were expelled. Care was taken that all the patients in these groups received exactly the same diet and exactly the same previous purgation. (See Table 15, page 134.)

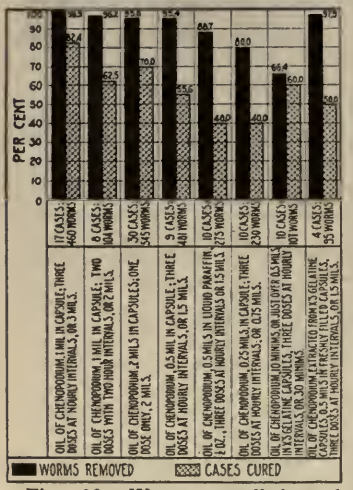

Fig. 33.—Worms expelled and cases cured by chenopodium in various doses. Single trial treatment. (Table 15)

The Commission wished to learn whether, in order to get satisfactory results, it was necessary to administer the chenopodium in three separate doses. Experiments were therefore made on a series of 30 cases, a single dose of 2 mils being given. The interesting result was that 95.8 per cent of the total number of worms present were removed, and 70 per cent of all the cases treated were cured. (See Table 15, page 134.)

Relative Costs of Treatment. An attempt was made to estimate the relative costs of treatment by chenopodium and by thymol. Figures were preserved and tabulated, based on actual experiments made among sixteen different groups. At the time of the particular treatments mentioned (February, 1917) the price of chenopodium was 1.84 cents per mil, and the price of thymol was 0.15 cent per

grain. The most satisfactory results, as far as the removal of worms was concerned, were obtained with one treatment of chenopodium—3 mils, administered in 3 doses, each dose consisting of 1 mil. On this basis, the cost per individual for the chenopodium treatment therefore amounted to 5.52 cents. Proper comparison of costs can be made only by using the dosage of thymol which proved to be most effective in removing worms, viz., one treatment consisting of 90 grains, administered in 3 doses of 30 grains each. On this basis the cost of the thymol treatment per individual was 13.5 cents. It will therefore be seen that treatment with chenopodium costs less than one-half as much as treatment with thymol.

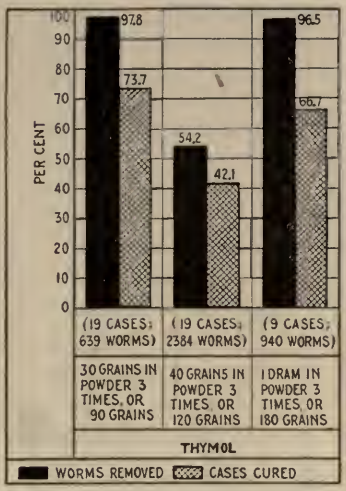

Fig. 34.—Worms expelled and cases cured by thymol in large doses. Single trial treatment. (Table 16)

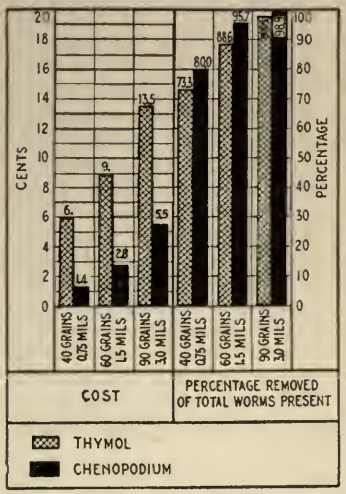

Fig. 35.—Cost of thymol and chenopodium, with comparative efficacy based on worms expelled. (Table 18)

These data involve a consideration that is of importance economically when mass treatment of populations numbering millions is contemplated. (See Table 18, page 138.)

After-effects of Treatment. Observations were made with respect to the after-effects of treatment, such as dizziness, unsteadiness of gait (drunkenness), inability to rise, semi-comatose state, tingling of hands and feet, deafness, burning in the stomach, and headache. All of these, except the last two, were more commonly complained of after the use of chenopodium than after treatment with any other vermicide. (See Table 19, page 139.) Streaks of blood in the vomitus were occasionally noted. These were probably due to the strain of vomiting, whether thymol or

chenopodium was used. Giddiness was always experienced, usually after the second dose, by all persons; it was more marked among men than among women. Not infrequently all the men would be lying down, giddy, after the third dose, while the women would be sitting up, talkative and cheerful. The manifestation of this minor physiological symptom was always to be desired, since it was indubitable evidence that the drug had been taken.

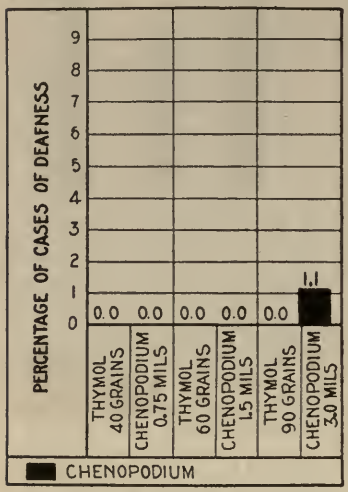

Fig. 36.—After-effects of thymol and chenopodium — incidence of deafness. (Table 19)

Experience with regard to the after-effects varied among the people treated in the different localities. The more severe symptoms were very rarely complained of by the dessa people in Java, who received treatment with chenopodium as an emulsion. For example, only one out of 175 persons so treated complained of deafness. On the other hand, in a jail where the prisoners were treated with the raw oil of chenopodium in capsules, from 16 to 20 per cent complained of deafness.

In a hospital ward it was somewhat difficult to ascertain the degree of discomfort experienced, for each person was very likely to answer a question just as the one before him had answered it. In order that this possibility of error might be obviated, all the men on one side of the ward would be given magnesium sulphate and all the men on the other side would be given castor oil, both before and after the treatment with chenopodium. It was observed that giddiness and deafness were more often experienced by the men who had been given castor oil than by those who had been given magnesium sulphate. At the time of the "parade," when each man had to rise, pick up his pot, walk out to the veranda, and exchange the pot for a fresh one, it was quite noticeable that the castor oil group contained the men who were suffering more severely from the effects of the drug. Sometimes they were unable to walk, or even to rise from their beds, without assistance.

Among the immediate after-effects of treatment by vermicidal drugs may be noted the effect on the hemoglobin of the patients. A temporary fall, or net loss, was observed after treatment by chenopodium when the normal hemoglobin of patients was from 61 to 70 per cent. Similarly a net loss in erythrocytes was observed after

treatment by chenopodium when the patient's hemoglobin normally registered 80 per cent and over. In anemia cases, on the contrary, the increase of hemoglobin or erythrocytes was not interfered with by the administration of chenopodium. In fact, both would mount almost immediately after treatment, and within a week would return to normal. Relapse cases of malaria following the administration of chenopodium were examined, in order to determine whether or not the relapse might be due to an attack of malaria superinduced by the drug. No relationship of cause and effect was indicated.

Excretion of Chenopodium and Albuminuria in the Urine. Investigations were undertaken to ascertain the possible toxic effects of chenopodium upon the kidneys, as well as the amount of absorption and rate of excretion of the drug. The presence, or absence, of albumin in the urine is determined by the heat and acetic acid test. To find the presence of chenopodium some urine is pipetted upon a surface of concentrated nitric acid. If resins are present a white ring, suggestive of albumin, will form at the junction of the fluids. This ring, however, differs from that which is formed by albumin, in that it forms at a slightly higher level in the urine and is most readily soluble in alcohol. In concentrated urine a pink ring forms at the junction of the acid and the urine, and this pink blends with the white ring that forms just above it.

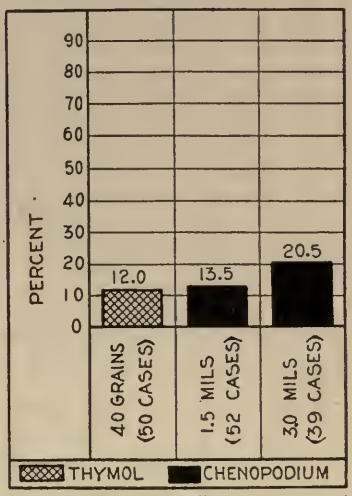

Fig. 37.—After-effects of thymol and chenopodium — incidence of albuminuria. (Table 19)

In albuminous urine the rings caused by albumin and resin form together, but on the addition of alcohol a cloud due to albumin still remains. Two or three drops of absolute alcohol are sufficient to dissolve the resin; but the albumin will remain until the concentration of alcohol is reached, at which time its oxidation by the nitric acid takes place. Some attempts were made to obtain a quantitative estimate of the amount of resin present; the attempts were based upon the finding, by titration, of the amount of diluted alcohol required to dissolve the ring. The results of these trials, however, were not sufficiently constant to be of any value. No attempt was made to determine gravimetrically the amount of resin present.

The fact that greater absorption, as shown by greater toxic symptoms, took place when castor oil was used as a purge than when

salines were employed, was confirmed by the relative size and opacity of the rings present. The test was made 6 hours after the castor oil had been given, in doses of 10 minims, 3 times, in soft capsules. The 5 cases to which castor oil was given were all positive, and had much heavier rings than the 5 cases to which magnesium sulphate was administered; among the latter, 2 showed no reaction.

That more absorption takes place with the larger dose of chenopodium (3 mils) than with the smaller dose (1.5 mils) was indicated by the greater toxic symptoms produced, and was confirmed by the incidence of the reaction in the urine and the opacity of the rings obtained. This was substantiated in two series of experiments. In one series, each of 26 cases was given 1.5 mils of chenopodium, and of that number 12, or 46.2 per cent, showed positive reactions. In the other series, each of 86 cases was given 3 mils of chenopodium, and of that number 70, or 81.4 per cent, showed positive reactions. The rings were much heavier in the second series than in the first.

That the excretion of chenopodium, particularly the resinous part, was slow (sometimes not being completed in five days) was also shown by a series of experiments. The length of time during which the reaction lasts in the urine was determined in a series of 12 cases, each of which was treated with 3 mils of chenopodium. In 7 of these cases a reaction was obtained for as long as 126 hours after the administration. In 5 of the 7 cases no albumin was revealed by the boiling test throughout the observations—which were made twice daily—and hence no difficulty was presented in the determination of the presence or absence of resins. The other 2 cases did develop albumin, but the presence of resin was inferred from a partial solution of the ring formed.

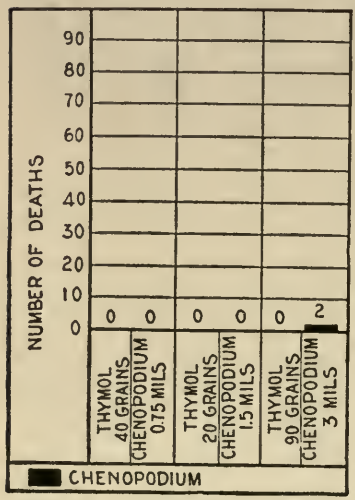

Fig. 38.—After-effects of thymol and chenopodium—deaths. (Table 19)

When the severe toxic symptoms, such as coma and deafness, occurred they generally were evident after the second treatment. In the earlier part of the work of the Commission, the second treatment was given on the fourth day, in order that the patients might be released within a week. But the results just indicated as to excretion made it clear that this procedure was not advisable. There was always the danger that the

second dose might produce toxic effects by accumulation, if given before all the drug from the first treatment had been excreted.

Although no deafness or coma occurred after administration of the lower doses of chenopodium (1.5 mils), it is to be noted that the highest dose of chenopodium (3 mils) occasionally produced these toxic effects on the nervous system. With even the highest doses of thymol, on the other hand, no serious toxic symptoms were noted—nothing more than giddiness.

Among the after-effects of treatment by chenopodium, there was one case of exacerbation of symptoms of dementia praecox. Only two cases of death occurred as the result of treatment, and in both of these cases full chenopodium treatments had been given within four days. After these two fatal instances, and in all the later work of the Commission, the second treatment was never administered until an interval of at least one week had elapsed.

Incidence of Vomiting. In some of these experiments there was vomiting after the first treatment only; in some, after the second treatment only; in some, after both treatments; and in some, after neither. When vomiting occurred it usually took place directly after the second purge was administered, and after the second dose of vermicide. The percentage of worms found and removed, both Ancylostomes and Necators, varied considerably in the different series. This difference in the relative efficiency of the several doses was probably due, at least in part, to the vomiting.

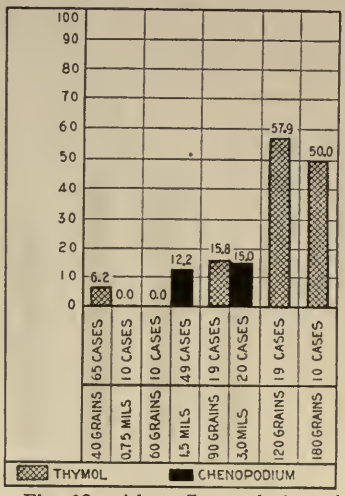

Fig. 39.—After-effects of thymol and chenopodium—incidence of vomiting. (Table 19)

Strong peppermint lozenges were sometimes given in order to prevent this vomiting if possible. When there was such vomiting the drug was usually repeated; not infrequently the vomitus contained portions of the vermicide. The amount of vomiting varied considerably and interfered not a little with the efficiency of the treatment. It is quite possible that this reaction may have been due to the taking of food secretly obtained, or it may have been due to other and unknown causes. A certain amount of vomiting is always to be expected in the treatment of cases not under absolute control.

At Taiping Jail, in the course of the experiments performed there, the dose of chenopodium which caused vomiting resulting in loss

of efficiency was not actually reached, although 3 mils were given. But in the experiments at the District Hospital at Kuala Lumpur, 46.9 per cent of vomiting occurred with loss of efficiency at a dosage of 2.8 mils. The heavier doses of thymol (120 grains and above) removed fewer worms than the lighter doses, because the vomiting that occurred reduced the amount of drug retained in the stomach to considerably below the quantity required for the efficient removal of worms.

Experiments with Purges. In order to determine what effect, if any, the kind of purge used had upon the value of the treatment, a series of cases were treated in which the purge administered was varied. To one

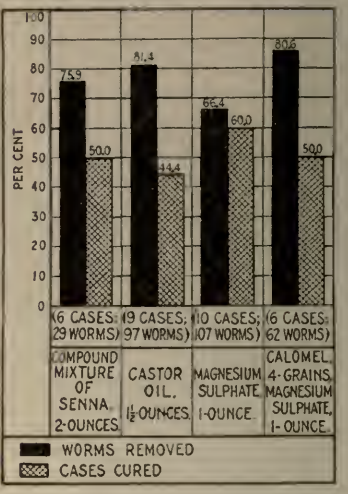

Fig. 40.—Experiments with various purges in chenopodium treatment. (Table 20)

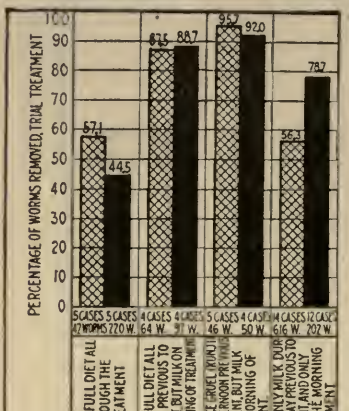

Fig. 41.—Results obtained by varying diet and omitting initial purge in treating hookworm disease with chenopodium. Trial treatment. (Table 21)

group, compound mixture of senna (2 oz.) was given; to another, castor oil (1½ oz.); to another, magnesium sulphate (1 oz.); and to another, calomel (4 gr.). If these experiments proved anything, they proved that there is little or no choice among the several purges, with respect to value and efficiency. (See Table 20, page 141.)

Diet. The standard routine diet established consisted of rice and gruel (kunji) on the afternoon previous to treatment, and milk on the morning of treatment. This diet gave by far the best results. It was adopted only after a series of cases were treated, with the diet varied. Some of the groups in the series received previous purgation, and some received none. (See Table 21, page 142.)

Fig. 42.—Hookworm patient, just before being discharged from Kuala Lumpur hospital. Showing good physical condition after removal of 604 hookworms

Fig. 43.—Severe case of hookworm anemia in Chinese youth shortly after admission to hospital. Hookworms expelled, 580; malaria, before admission; spleen, negative; hemoglobin, 5%

Fig. 44.—Same case as Fig. 43, after treatment. Note disappearance of edema

Fig. 45.—Same case as Fig. 43, during convalescence

Fig. 46.—Same case as Fig. 43, after recovery. Hemoglobin, 45%

Fig. 47.—Group of former residents of Federated Malay States and Straits Settlements examined at St. John's quarantine camp, Singapore. Note fine physical condition of coolies re-entering when free of hookworm and malaria

CHAPTER VI

FINDINGS CONCERNING HOOKWORM INFECTION

Work at Port Swettenham. At Port Swettenham the Commission examined the stools of 2,262 persons, of whom 1,736 were men, 384 were women, and 142 were children under 12 years of age. Of this total number examined, 2,188, or 96.7 per cent, were found to be positive for hookworm ova, but inasmuch as stools for second and third examinations were obtained from only 45 of the 74 cases found to be negative, it is perhaps reasonable to assume that the actual percentage was nearer 99 per cent than 96.7 per cent. (See Table 22, page 143.)

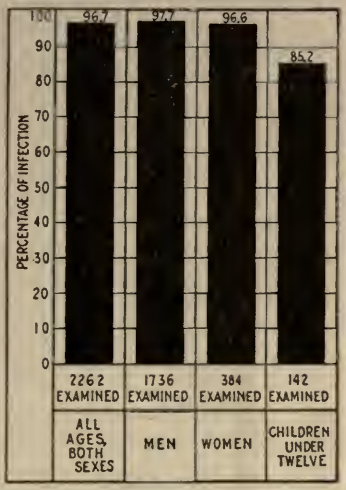

Fig. 48.—Results of examinations for hookworm disease at Port Swettenham. (Table 22)

Relation between Patient's Age and Degree of Infection. Examination of the stools of children under twelve years of age showed clearly that a high rate of infection occurs very early in life, and that it progresses rapidly until the average percentage for adults is reached. These conclusions with reference to the relation between age and hookworm infection are based upon the analysis of results obtained from experiments among persons of twelve years and under. (The data are presented in Table 23, page 144.)

Vulnerability of Worms to Vermicide in Relation to Species and Sex. The Commission found reasons for believing that the various kinds of worms differ in their resistance to a given dose of vermicide—that Necators are less resistant than Ancylostomes, and that males in each species are less resistant than females. This resistance to vermicide was thought to vary with species and sex, increasing as the size of the worm increases. In order that this theory might be verified, a study was made of a series of cases in which chenopodium was used as the vermicide.

In the first treatment, the total number of worms removed was 4,296, of which number 3,871, or 90.1 per cent, were Necators and

425, or 9.9 per cent, were Ancylostomes. Of the 3,871 Necators removed, it was found that 1,897, or 49 per cent, were females and 1,974, or 51 per cent, were males. Of the 425 Ancylostomes removed, 202, or 47.5 per cent, were females, and 223, or 52.5 per cent, were males.

In the second treatment, the total number of worms removed was 217, of which number 108, or 49.8 per cent, were Necators, and 109, or 50.2 per cent, were Ancylostomes. Of the 108 Necators removed, 70, or 64.8 per cent, were females, and 38, or 35.2 per cent, were males. Of the 109 Ancylostomes removed, 93, or 85.3 per cent, were females, and 16, or 14.7 per cent, were males.

In the third treatment, the total number of worms removed was 39; of that number, 19, or 48.7 per cent, were Necators, and 20, or 51.3 per cent, were Ancylostomes. Of the 19 Necators removed, 16, or 84.2 per cent, were females, and 3, or 15.8 per cent, were males. (See Tables 24 and 24A, pages 145 and 146.)

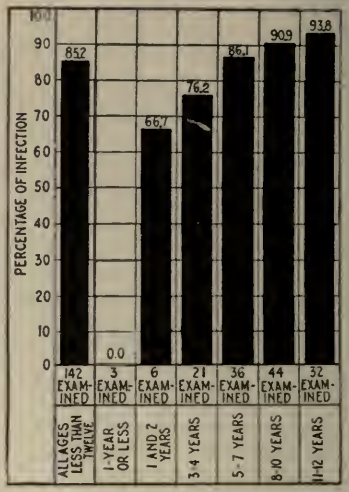

Fig. 49.—Hookworm infection rates, by age groups, for children less than twelve years old. Examinations at Port Swettenham. (Table 23)

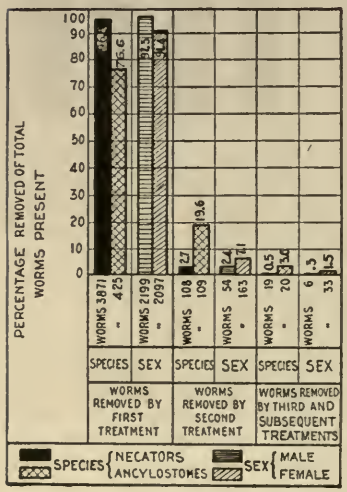

Fig. 50.—Vulnerability of worms in relation to species and sex. (Tables 24 and 24A)

In the first treatment, as has been stated, slightly over 90 per cent of the worms removed were Necators and only slightly under 10 per cent were Ancylostomes, and after a later treatment the Ancylostomes predominated and steadily increased in proportion, while the Necators as steadily diminished in proportion. These data indicate that the Necators succumb more readily to the first treatment, while the results of later treatments consist for the most part in the expulsion of the more resistant Ancylostomes.

Furthermore, it will be noted that in the first treatment males predominated in both species, while in later treatments females predominated and assumed a greater proportion to the males after each successive treatment. These facts show that the females are more resistant to the drug than the males. This fact is further substantiated in Table 24A, page 146, which also shows that the Necators are more readily removed than the Ancylostomes, and that in each species the males are more easily removed than the females.

Vulnerability of Worms in Relation to Dose of Vermicide. In brief, as a result of their various investigations and experiments, the Commission arrived at the following definite conclusions concerning the relationship between the amount of vermicide administered and the effect which the vermicide has on a given form of worm:

Lower doses of vermicide, as compared with the higher doses, are more effective against the less resistant forms of worms.

These lower doses are relatively ineffective, however—as compared with the higher doses—against the more resistant forms.

The difference between the effects of vermicide on the less resistant and the more resistant forms, respectively, becomes less as the dose is increased.

Finally, the larger doses of vermicide are generally of particular use in getting rid of the more resistant forms.

It will be seen by reference to Table 25, page 147, that there is considerable difference between the effects of the higher and the lower doses of vermicide on different classes of worms. In the case of the lower doses the difference in effect upon the less resistant and the more resistant forms, respectively, is seen to be 38.6 per cent, while with the higher doses the difference is 21.3 per cent.

In all these experiments, chenopodium was the vermicide used. A series of similar experiments in which thymol was employed, also showed that in the case of the lower doses the difference between the effects on the more susceptible and the more resistant worm types, respectively, was large—42.1 per cent; with the higher doses the difference was inconsiderable—only 4.7 per cent. These facts are clearly revealed in Table 26, page 148.

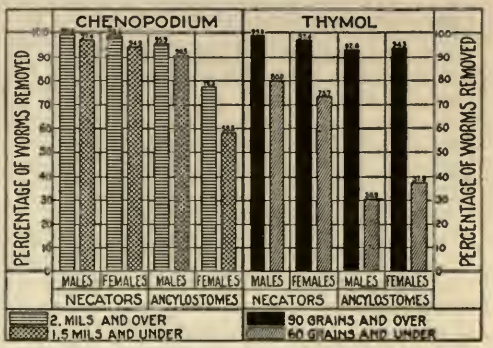

Fig. 51.—Effect on Necators and Ancylostomes of varying dosages of thymol and chenopodium. Single trial treatment. (Tables 25 and 26)

Relation between Number of Worms Present and Facility with Which They Are Removed. As a result of a number of experiments the Commission was convinced that it is easier to remove a high percentage of worms when there are many worms present than when there are few. All the data were obtained in those cases in which two treatments of the same drug were given. The effect of the first treatment on the total number of worms may be compared with the effect of the second treatment on the much smaller number of worms left after the first treatment. The percentage of worms removed in the first treatment, when the number of worms naturally is relatively large, was compared with the percentage of worms removed in the second treatment, when the number of worms is relatively small. Thus, when chenopodium was used (.5 mil three times), the first treatment removed 95.7 per cent of the total number of worms present. The second treatment removed 77.6 per cent of the total number of worms remaining after the first treatment. In the case of all the drugs and all the methods of treatment which were employed and for which comparative statistics are available, the combined figures indicate a similar disparity. When the total number of worms present was 5,636, the first treatment removed, on the average, 82.3 per cent; and when the total number amounted only to 997, the percentage removed by the second treatment was only 37.3. It was therefore perfectly clear that the percentage of worms removed in each case was greater when the number of worms was large than when it was small. (See Table 27, page 149.)

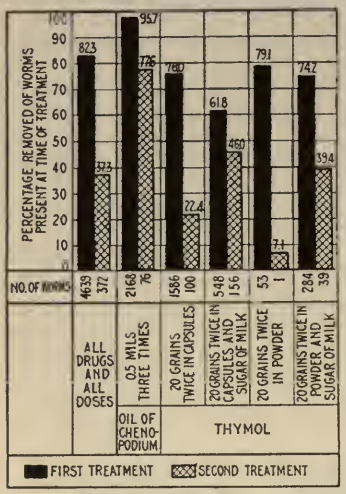

Fig. 52.—Difficulty of expelling worms when number harbored is small. (Table 27)

Regarding the comparison of the results of the first and second treatments, with the same dose, of the same drug, on the same cases, certain objections might be raised. For example, it might be said that there may have been a difference in the resistance of the worms in the first treatment; or that the high percentage of worms removed may have been due to the removal of the less resistant worms, while, on the other hand, in the second treatment, the percentage may have been lower because the drug was acting on the more resistant worms which remained. That this is not the true explanation may be seen

by noting the effect, on the different cases, of treatment with various drugs, and by comparing these results in the 56 cases in which the average number of worms per case was less than 10, with results in the 16 cases in which the average number of worms was more than 50. It becomes evident from such a comparison that in those cases with the number of worms over 50 (in which the average number of worms was 106) the percentage of worms removed (i. e. 87.5) was higher than the percentage (i. e. 80.0) in cases in which the worms were fewer than 10—an average of 4.5 worms per case.

Work at District Hospital at Kuala Lumpur. For a period of five consecutive months, the Commission worked in the District Hospital at Kuala Lumpur. During this period 1,300 Chinese and 650 Tamils were admitted. Post-mortem examinations were made on 103, or 40 per cent, of the total number of fatal cases. These examinations revealed 35 types of disease. When the total number of deaths due to malaria was compared with the total number of deaths due to hookworm disease, it was found that there were five times as many due to the former as to the latter, and that there were 2.3 times more deaths from malaria among the Tamils than among the Chinese.

In the sectioning of the bodies, the intestinal tracts were carefully searched for helminths. Spleen and marrow samples were examined for malaria plasmodia or pigment, and tissues were sectioned for microscopic diagnosis. The analyses of the post-mortem cases furnished a good basis for comparing the incidence of various diseases that proved fatal, as they occurred in the two races. The basis for comparison was particularly accurate since the distribution of the races, in the post-mortems and in the cases admitted to the Hospital during the period, corresponded closely with the numbers of the respective races in the population at large in the state of Selangor. Among the various distinct types of disease occurring in the two races, dysentery, malaria, and tuberculosis were the most common; those due to external causes were found to be relatively few in number (7.7 per cent of the total) and were confined to the Chinese.

Further investigations at the same Hospital disclosed the fact that whereas the number of Tamils admitted because of severe hookworm infection was disproportionately great, when compared with the number of Chinese, there were no deaths certainly traceable to hookworm infection among them, while among the Chinese there were four deaths attributable to that cause. In other words, while there were 66 Chinese to 34 Tamils constantly present in the hospital throughout the year, there were among the cases of severe anemia admitted to the Commission's ward, 6 Tamils having over 500 worms, with no deaths, and 5 Chinese having over 500 worms, with a record of 4 deaths out of 5. It would appear from these facts that while Tamils may harbor many worms and may suffer severe anemia, there is no record of mortality. While the Tamils examined were found to

harbor almost as many hookworms as the Chinese and while their hemoglobin was nearly as low, none of them died.

This difference in the severity of the disease as between the two races may possibly have been due to the fact that the mouth parts of the *Ancylostoma duodenale*, a species of which the Chinese had the larger proportion, are larger than the mouth parts of the Necator. This anatomical difference would enable the former to inflict more serious wounds in the mucosa, thus causing a greater degree of anemia. (For certain clinical studies see Chapter VII, page 65.)

Work at Singapore. At the quarantine camp on St. John's Island, Singapore, research and investigation work was undertaken for much the same purpose as that which actuated operations at Port Swettenham, except that the coolies were Chinese instead of Tamils. Indians examined at Port Swettenham came, for the most part, from the southern districts of India. Most of the Chinese examined at Singapore came from the southern provinces of China. A considerable percentage of the Chinese who entered the Malay Peninsula at Singapore had a history of previous residence other than China—usually the Malay Peninsula. Of the 304 whose feces were examined microscopically but who were not treated, 203, or 66.8 per cent, were found positive for hookworm ova. Of these Chinese immigrants, 88 were treated for hookworm infection. Of the 88, as many as 60 had no previous residence other than China, and the former residence of most of the remaining 28 was the Malay Peninsula. The newcomers also proved to harbor a larger average number of hookworms than those who had been longer in the Malay Peninsula. That is, there were 31.5 worms per individual among the 60 persons who had resided previously only in China, as against the 20 worms per person among the 28 who had had a former residence other than China. The average hemoglobin in both groups was found to be practically the same. Of the 88 who were treated, 62 were men, 20 were women, and 6 were children. The percentage of hookworm infection among the men was 90.3, among the women 85, and among the children 83.3. The gross percentage of hookworm

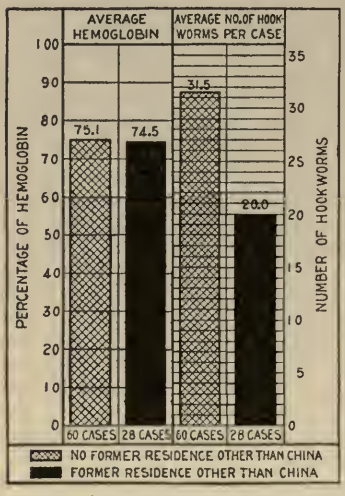

Fig. 53.—Average hemoglobin and average number of hookworms harbored by eighty-eight Chinese treated at Singapore. (Table 28)

infection among men, women, and children was 88.6. The average hemoglobin percentage among the men was 77.5, among the women 65.5, and among the children 79.5. As to both hookworm infection and average hemoglobin, practically the same percentages were found among the immigrants who were treated at Singapore as among those who were later treated in the Federated Malay States. (See Table 28, page 150.)

Work in the Fiji Islands. Hookworm infection, it was found, prevailed in the island of Viti Levu (Fiji) to as great an extent as in the Federated Malay States and in Java. In fact, in the adult male Indian and Fijian populations the incidence was found to be 100 per cent. There is no doubt that hookworms were brought into the country by Indian immigrants; but severe infections were also encountered among the aboriginal inhabitants of the island. In all, 190 cases were examined, including Indians, Fijian half-castes, and Europeans; these cases included both adult males and females, and children. Of this total number, 183, or 96.3 per cent, were found to be infected. Half-castes and European children were found to harbor very few worms, although they run barefooted throughout the year and are thus exposed to infection. European adults were found to be free from hookworm ova—except those who were born in Fiji; these, in all likelihood, had acquired infection during youth or adolescence while going barefooted. (See Table 29, page 151.)

Among the indentured coolies who underwent medical inspection and hookworm treatment as well, whenever clinical evidence of anemia existed there was some mild anemia. Only two cases of severe anemia were detected.

The free coolies who live out in the flat, wet cane-fields were all heavily infected. On their premises the ground water was high and the shallow latrines in use were by no means sanitary. Among this class there were cases of anemia of all grades, from severe to mild, and their condition, as exhibited at the time of muster and as recorded by the hemoglobinometer, was distinctly below that of the indentured men. These free coolies are not obliged to submit to medical inspection, and do not receive free hospital treatment. Consequently they had received no hookworm treatment since the expiration of their period of indenture, from five to twenty years before. They were found to be very approachable, and no difficulty was experienced in persuading them to enter the Hospital for thorough treatment.

The hookworm campaign now being conducted by the Fiji Medical Department, with the co-operation of the International Health Board, reaches a similar class of free coolies, and should result in considerable improvement in their physical condition. These people are for the most part thrifty farmers on a small scale. Since they are disposed to be exceedingly frugal in eating, it is quite probable that the anemia caused by hookworm infection is intensified in this class by chronic conditions of innutrition.

RACE	CONDITION, OCCUPATION, ENVIRONMENT, ETC.	NATIVE PLACE	NO. OF CASES	PER CENT ANCYLOSTOMES
MALAY	SCHOOL BOYS, KAMPONG BHARU	MALAYA, K.L.	38	.22
MALAY	SCHOOL BOYS, ULU GOMBAK	MALAYA, ULU GOMBAK	39	.8
MALAY	MALAYS, 13 MALES AND 3 FEMALES BORN IN FEDERATED MALAY STATES	MALAYA	16	.9
MALAY	MALAYS BORN IN JAVA, LOCATION UNKNOWN	JAVA	12	2.6
MALAY	MALAYS BORN IN SUMATRA	SUMATRA	28	2.1
MALAY	MALAYS BORN IN SUMATRA, JAIL SERIES, BATAVIA	SUMATRA	12	.8
MALAY	MALAYS, BATAVIA KAMPONGS	WEST JAVA	83	.9
MALAY	SUDANESE, PREANGER, KAMPONG ENDIL	PREANGER, JAVA	25	.16
MALAY	SUDANESE, PREANGER, TJIMATJAN	PREANGER, JAVA	25	.0
CHINESE	STRAITS-BORN CHINESE	MALACCA, S.S.	2	.0
CHINESE	BATAVIA-BORN CHINESE	BATAVIA	1	.8
MALAY	CELEBES, JAIL SERIES, BATAVIA	CELEBES	4	.0
TAMILS	FROM MADRAS, INDIA. WORMS RECOVERED FROM TREATMENTS	SOUTH INDIA	7	3.0
TAMILS	TREATMENTS, TAMILS RECENTLY FROM MADRAS	SOUTH INDIA	34	2.0
MALABARIS	PATIENTS, HOSPITAL NO.1, FEDERATED MALAY STATES	SOUTH INDIA	25	.86
TAMILS	ROAD COOLIES, FEDERATED MALAY STATES	SOUTH INDIA	35	2.1
SIKHS AND PATHANS	POLICE, FEDERATED MALAY STATES	NORTH INDIA	13	69.4
CHINESE	FATAL CASES OF SEVERE HOOKWORM DISEASE (POST MORTEM RECORDS)	SOUTH CHINA	5	86.1
CHINESE	NEWCOMERS FROM CHINA, "SINKEHS"	SOUTH CHINA	46	33.8
CHINESE	PATIENTS, HOSPITAL NO.1, FEDERATED MALAY STATES	SOUTH CHINA	79	38.6
CHINESE	ESTATE COOLIES, SUMATRA, JAIL BATAVIA	SOUTH CHINA	13	30.4
MALAYS	SUMATRA MALAYS, PROBABLY INFECTED FROM CHINESE SOURCES	SUMATRA	2	65.8
TAMILS	NIGHT-SOIL COOLIES, FEDERATED MALAY STATES, INFECTED FROM CHINESE	SOUTH INDIA	57	11.1
TAMILS	PATIENTS, DISTRICT HOSPITAL, INFECTED FROM CHINESE	SOUTH INDIA	118	5.1
JAVANESE	JAVA, GEBONGILER, KAMPONGS	MID-JAVA	50	13.2
JAVANESE	JAVA, KALIMARO, KAMPONGS	MID-JAVA	24	6.3
JAVANESE	JAVA, KEBASEKAN, KAMPONGS	MID-JAVA	25	5.4
JAVANESE	JAVA, KRAKAL-KARANGSARI, KAMPONGS	MID-JAVA	28	7.1
JAVANESE	PRISONERS, JAIL, BATAVIA	MID & EAST JAVA	9	7.5
MADURESE	PRISONERS, JAIL, BATAVIA	MADURA	16	13.7
BALINESE	PRISONERS, JAIL, BATAVIA	BALI	5	4.0
TIMORESE	PRISONERS, JAIL, BATAVIA	TIMOR	4	61.0
LOMBOKANS	PRISONERS, JAIL BATAVIA	LOMBOK	4	3.3
CHINESE	CHINESE BORN IN MID-JAVA, SEMARANG	MID-JAVA	1	19.3

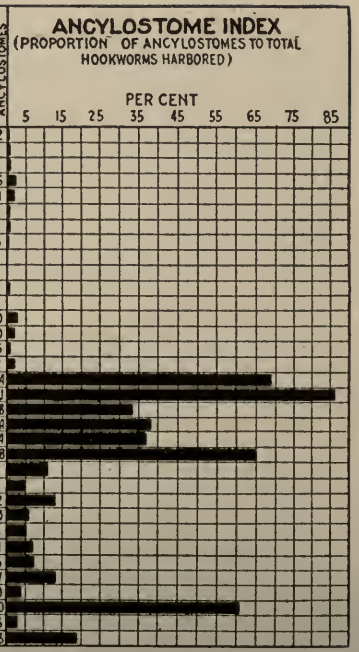

Fig. 54.—Hookworm-species formula according to race, occupation, environment, etc. (Table 30)

The native population represented by Fijians living in remote districts, out of contact with Indian sources of hookworm infection, was found to harbor *Necator americanus* and *Ancylostoma ceylanicum* (the latter being derived from the dogs). *Ancylostoma duodenale* was entirely absent. This leads to the conviction that *Necator americanus* is a natural parasite of the Fijians, and that very likely Polynesians as well as Melanesians will be found to harbor this species exclusively, except in places where the people may be living in contact with Asiatics who harbor *Ancylostoma duodenale*.

HOOKWORM-SPECIES FORMULA ACCORDING TO RACE

The species was always very carefully determined in the case of all the hookworms that were recovered in the course of treatment, and a careful tabulation made of the distribution of species in representatives of the various races and of the effect of occupation and environment in such distribution. As a result it was found that the proportion of Ancylostomes to Necators varied considerably in the different races. (See Table 30, pages 152 and 153.) Evidence was also found that both occupation and environment tend to limit or to influence the proportion of the species of hookworms with which certain individuals are infected. The distribution and relative numbers of *Ancylostoma duodenale* are important on account of their relation to effective and economical treatment. For, since there is a definite relation between dosage of drug and respective species of worm (more drug being required to dislodge the more resistant *Ancylostoma duodenale*), it is highly desirable to know the Ancylostome formula of the people who are being treated. If this is known it is comparatively simple to adjust the dosage of the drug efficiently and economically, according to the species of worms which are to be removed. It has been found convenient to express the hookworm-species formula in terms of percentage of Ancylostomes, because, this being the more difficult worm to remove by anthelmintics, such terms indicate in the best manner the degree of necessity of using larger dosages of the vermicide.

Malays. At Kampong Bharu, 38 kampong boys were treated. These were found to harbor a total of 2,262 hookworms, of which number 2,257 were *Necator americanus*, and 5 were Ancylostomes. Of these 5 Ancylostomes, 2 were *A. ceylanicum* and 3 were *A. duodenale*. It will thus be seen that the percentage of Ancylostomes among these boys was only 0.22. The boys of this kampong, so far as their customs indicate, probably re-infect one another, for they are not to any extent subject to infection by Chinese, Tamils, or others, inasmuch as they live within their own kampongs.

The Malay kampong at Ulu Gombak yielded very much the same results. At the kampong 39 boys were treated, and from them a

total of 1,559 hookworms were recovered, of which number 1,546 were *Necator americanus* and 13 were Ancylostomes. Of these 13 Ancylostomes, 6 were *A. ceylanicum* and 7 were *A. duodenale.* It will thus be seen that the percentage of Ancylostomes among these boys was 0.8. It is also noteworthy that nearly one-half the the Ancylostomes harbored were *A. ceylanicum;* this species, while comprising about 60 per cent of the hookworms found in the dogs of Kuala Lumpur, was only rarely found in adult Chinese or Tamils.

The adult Malays were easily classed in three distinct groups. In the first group, consisting of Malays principally in the Malay Peninsula, there were 16 persons with a total of 1,138 hookworms, of which number 1,128 were *Necator americanus* and 10 were *A. duodenale.* The percentage of Ancylostomes in the first group was therefore 0.9 In the second group, consisting of Malays principally from Java, there were 12 persons with a total of 1,757 worms, of which number 1,711 were *Necator americanus* and 46 were *A. duodenale.* The percentage of Ancylostomes in this second group was therefore 2.6. In the third group, consisting of Malays principally from Sumatra, there were 28 persons, with a total of 2,746 hookworms, of which number 58 were Ancylostomes, including 7 that were *A. ceylanicum.* The percentage of Ancylostomes in this third group was therefore 2.1.

Chinese. The Chinese were found to fall into two groups. The persons in the first group consisted principally of those who came to the Federated Malay States, usually as adults, from the southern provinces of China. To a considerable extent their worm-species formula must therefore represent the infection received in China. Even after these people had spent a number of years in the Federated Malay States, their habits and their superior numbers would, as a rule, lead to their acquiring re-infection from one another rather than from other races. It may be assumed that the worm-species of the sinkehs, or newcomers from China, would give the proportion of the species as it exists in the people from the southern provinces of China. Forty-six sinkehs were treated at the quarantine camp at St. John's Island, Singapore. From them 1,241 worms were obtained, of which number 420 were *A. duodenale* and 821 were *N. americanus.* Thus the gross percentage of Ancylostomes was 33.8. There were 10 cases of purely Necator infections in this group, which harbored a total of 148 worms. Of the whole group, 36.9 per cent fell within the formula.

Among the cases treated at the District Hospital at Kuala Lumpur there were 79 Chinese, who yielded 5,191 hookworms, of which number 1,994 were *A. duodenale* and 3,197 were *Necator americanus.* The percentage of Ancylostomes in this group was 38.4. It is interesting to observe that there were 12 cases in this group with infections from *Necator americanus,* and 37 other cases whose percentage of Ancylostomes was below the apparent average for the whole group. The men of this group had lived in the Federated Malay States for

varying periods up to twenty years. It is entirely possible that they represented to some extent examples of infections acquired from other races. The soil and climate of the Federated Malay States did not seem inimical to the larvae of *A. duodenale*, for the group consisted of 33 examples of men who were infected with this species, and who had lived in the country from 10 to 20 years. Therefore, they had undoubtedly acquired the infection during the term of their residence.

Straits-born Chinese. Only two cases of Straits-born Chinese were treated. Nevertheless, the results found were significant, for the species formula is that of the natives of the country, and not that of the Chinese. These two men were hospital dressers, born in Malacca. One of the two cases represents the first generation, the other the second generation, born in the country. On treatment, one yielded 42 Necators and the other yielded 30 Necators. Ancylostomes were not obtained from either. The percentage of Ancylostomes, therefore, in these two Straits-born Chinese was nil.

Tamils and South Indians. The natives of South India—Tamils, Telegus, and Malabaris—have a worm-species formula approaching very closely that of the Malays of the Federated Malay States.

During the time that treatments were being carried out at the Port Swettenham quarantine camp, 10,455 hookworms were recovered, of which number 312 were *A. duodenale* and 10,143 (the remainder) were *N. americanus*. The percentage of Ancylostomes, therefore, was 2.9 among Tamils entering the country. A number of these 10,455 worms were obtained from three treatment squads. In these treatments, 4,363 worms were obtained, of which number 89 were *A. duodenale* and 4,274 (the remainder) were *N. americanus*. The percentage of Ancylostomes, therefore, in this sub-group, was 2.0. This percentage probably represents the proportion of the two species of hookworms among the natives of southern India.

During the early part of 1916, a number of Malabaris from South India who had lived in the Federated Malay States but a few months, were treated. Altogether there were 25 cases, yielding 3,491 worms, of which number 30 were *A. duodenale* and 3,461 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, among these Malabaris was 0.86.

The treated cases at the District Hospital included 118 Tamils who had resided in the Federated Malay States for varying periods up to twenty years. From these Tamils, 12,806 worms were obtained, of which number 658 were *A. duodenale* and 12,148 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, was 5.1. This percentage probably represents the modicum of infection suffered by Tamil residents in the Federated Malay States, where there is a large but scattered Chinese population with its high Ancylostome index.

The comparison of the species percentage composition of newly arrived Tamils, or Malabaris, with those Tamils who transported

and buried night soil obtained from the city of Kuala Lumpur (which has a large Chinese population), furnishes further evidence of the infection of Tamils from Chinese sources. Fifty-seven night-soil coolies (men, women, and children) were treated. These coolies had followed their vocation for periods varying up to eleven years. The total number of worms harbored by this group of 57 persons was 7,259, of which number 806 were *A. duodenale* and 6,453 (the remainder) were *N. americanus*. The percentage of Ancylostomes, therefore, in this group of coolies, was 11.1.

Undoubtedly this percentage represents the infection derived from Chinese sources by the handling of night soil. This group of coolies was compared with the group of Tamil coolies engaged in road-repairing. Those in the latter group were not exposed to hookworm infection in the same degree as were the night-soil coolies. A group of 35 road coolies were treated. This group was made up of men, women, and youths. None in the group had ever worked as a night-soil coolie. They had all lived in the Federated Malay States for periods varying up to fifteen years, sometimes employed on estates and sometimes on public works. As the result of treatment they yielded 2,870 worms, of which number 59 were *A. duodenale* and 2,811 (the remainder) *N. americanus*. In this coolie group, whose members were not especially exposed to infection from Chinese sources, and in whom the South Indian formula was retained, the percentage of Ancylostomes was 2.0.

People of Northern India. It appears that the people of northern India have a species percentage composition differing from that of the people of southern India. There are relatively few people from northern India in the Federated Malay States, but the people of that region are represented in the Commission's series of Sikhs and Mohammedan police from the Punjab. These men, however, had lived in the Federated Malay States for several years and the Ancylostome index natural to them in their own country cannot be positively ascertained. Thirteen Sikhs were treated in Hospital No. 2. All who had lived in the Federated Malay States for periods of 10 years or over, or who had worked on estates, were excluded. It was found that the 7 remaining men harbored only 41 hookworms, of which number 21 were *A. duodenale* and 20 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, in this group was 51.2.

On the other hand, if we take those who had lived for periods of 10 years or more in the Federated Malay States, or who had been employed on estates (where there would be more opportunity for acquiring infection by Necators), we have 3 cases harboring a total of 39 worms, of which number 5 were *A. duodenale* and 34 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, in this group, was 12.5. In Hospital No. 1, 8 Sikhs were treated. These may be separated into 2 groups, the first consisting of those who had lived in the Federated Malay States 10 years

or more, and the second group consisting of those who had lived in the Federated Malay States less than that time. Investigation revealed the fact that in the first group there were 6 cases, harboring a total of 83 worms, of which number 65 were *A. duodenale* and 18 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, in this group was 78.3. In the second group 2 cases were found harboring a total of 139 worms, of which number 6 were *A. duodenale* and 133 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, in this group was 4.3.

The conclusion which may be drawn from these figures is that the Ancylostome index of the people of northern India, at about 30 degrees N. latitude, would be found to be as high as that of the people in southern China, living at 23 degrees N. latitude.

Japanese. A group of four Japanese prostitutes who had been in the Federated Malay States three years or less, were treated. These 4 women were found to harbor 61 worms, of which number 19 were *A. duodenale* and 42 (the remainder) *N. americanus*. The percentage of Ancylostomes, therefore, in this group was 31.1. The indications are that the Japanese have, in common with the races farther north, a higher Ancylostome index than the natives of the Federated Malay States.

Europeans. Only three of the six Europeans (all planters) from whom hookworms were obtained upon treatment, had certainly acquired their infection in the Federated Malay States. The other three may have acquired it there, but inasmuch as they had lived in other tropical countries before coming to that country, it is perfectly possible that they may have acquired their infection elsewhere. Of the 3 men who had never lived in places other than the Federated Malay States where hookworm infection was known to occur, one harbored 8 worms, all of which were *A. duodenale;* another harbored 9 worms, 2 of which were *A. duodenale;* and the third man harbored 20 worms, 1 of which was *A. duodenale*. It is highly probable that the planters who become infected in the Federated Malay States derive their infection from mixed sources.

While it is comparatively easy to determine whether or not a group of Tamils have become infected from Chinese sources, it is extremely difficult to say whether Chinese old residents are being infected by Tamils or Malays. Recently arrived Tamils and Malays rarely harbored *A. duodenale*, or else harbored these worms in very small numbers. On the other hand, it is known that the Chinese harbored considerable numbers of *N. americanus*. Furthermore, about 15 per cent of the sinkehs, or newcomers, examined at St. John's Island, showed infection according to the Tamil or Malay formula; that is to say, among other worms a very large majority of Necators was found. There is, however, always some room for doubt in the case of a Chinese declaring himself a sinkeh; he may be a former resident who is disinclined to admit the fact.

Javanese. In Java there were geographical and racial differences in the proportion of the species of worms present. For example, in the kampongs of Batavia a total of 2,935 hookworms was obtained, of which number 26 were found to be *A. duodenale* and 2,909 (the remainder) *N. americanus.* In this group, the percentage of Ancylostomes was, therefore, 0.8. The same difference was found in Preanger. At Endil, 25 natives were treated and from them 1,275 worms were obtained, only 2 of which were Ancylostomes; both of these were *A. ceylanicum.* In West Java, in the three places visited, the proportion of Ancylostomes was found to be very small indeed. The worm formula, in fact, resembled that of the South Indians, the Sumatrans, or the natives of the Federated Malay States.

In Mid-Java, the Ancylostomes appeared in larger numbers in every kampong and were evenly distributed throughout the population. At Gebongelir, Mid-Java, 50 natives were treated and from them 2,339 worms were obtained, of which 308 were *A. duodenale* and 2,031 (the remainder) *N. americanus.* The percentage of Ancylostomes in this group was, therefore, 13.1. At Kalimaro, which is one and one-half miles away, 24 persons upon treatment yielded 5,140 worms, 322 of which were *A. duodenale* and 4,818 (the remainder) *N. americanus.* The percentage of Ancylostomes was, therefore, 6.2. At Kebasekan, the 25 persons who were treated yielded a total of 4,082 worms, of which 219 were *A. duodenale* and 3,863 (the remainder) *N. americanus.* Therefore, in this kampong, the percentage of Ancylostomes was 5.4. At Krakal-Karangsari, 28 natives were treated and from them 10,861 worms were obtained. Of this number, 770 were *A. duodenale* and 10,091 (the remainder) *N. americanus.* The percentage of Ancylostomes was, therefore, 7.0.

Thus, a well-marked difference was noted between the Ancylostome index of the Malays of Batavia and the Sudanese of Preanger on the one hand, with their universally low index, and the Javanese of Mid-Java on the other hand, with their uniformly higher index. The prisoners at the Batavia jail were treated and examined for evidences along these lines. These prisoners, in spite of the fact that there seemed to be no possibility of acquiring new hookworm infections in the jail, showed an Ancylostome percentage of 9.2 (with a total worm count of 8,683), while the people in the neighboring kampong—even within a stone's throw of the jail—had a low Ancylostome index. It would appear from this that their infection must have been acquired elsewhere, and, as a matter of fact, this theory was confirmed by separating the men into groups according to the particular part of the Netherlands Indies from which they came.

For example, there were 9 prisoners who gave their place of residence as Mid-Java or East Java, whose total worm count was 755, of which 57 were *A. duodenale.* In other words, they showed an Ancylostome percentage of 7.5. On the other hand, 2 persons who gave their place of residence as Batavia or Preanger showed an Ancylostome percentage of only 0.76, for out of a total of 130 worms yielded by these 2 persons, only one was *A. duodenale.*

Fig. 55.—Two cases of hookworm anemia in Mid-Java. The younger man was an imbecile and total worm count was not obtained. The other case harbored 843 hookworms. Spleen and plasmodia, negative; hemoglobins were 13% and 10% respectively

Fig. 56—Cases of hookworm anemia and malarial anemia contrasted. The Tamil harbored 1,063 hookworms; hemoglobin was 5-10% and spleen was negative. The Chinese harbored only 82 hookworms; hemoglobin was 30% and spleen was enlarged a hand's breadth

Sumatrans. Regarding the worm formulae of the prisoners coming from Sumatra and from the other islands in the Netherlands Indies, an equally well-marked difference was noted between the formula of the Malays from Sumatra, for example, and the formula of the natives of the islands of Madura, Bali, Lombok, and Timor. Madura is a small island almost touching the eastern end of Java. The inhabitants have colonized in East Java and are becoming assimilated. There were 16 prisoners from Madura, from whom 1,263 worms were obtained, of which 173 were *A. duodenale;* thus the Ancylostome percentage was 13.7.

The Ancylostome index of the natives found on the islands of Bali, Lombok, and Timor resembles that of the people of Mid-Java and East Java more closely than it does that of the people of West Java. Bali, with 5 cases having a total worm count of 348, gave an Ancylostome percentage of 4.0. Lombok, with 4 cases having a total worm count of 479, gave an Ancylostome index of 3.3; Timor, with 4 cases having a total worm count of 100, gave an Ancylostome index of 62.0 per cent.

Among those examined there were from Sumatra 12 cases, which fell into the group corresponding to West Java and Malaya. The total worm count of these 12 cases was 919, and of that total only 7 worms were *A. duodenale;* the Ancylostome percentage was therefore 0.9. There were two cases from Sumatra, with formulae resembling those of the Chinese. One of these two men was questioned at the time of examination, and was found to be a Madras Tamil employed as a cart-driver on a tobacco estate, where he lived for five years close to the Chinese lines. These 2 cases yielded 38 worms, of which 25 were *A. duodenale;* hence the percentage of Ancylostomes was 65.0. These data, of course, would seem to point to the fact that the men were infected from Chinese sources.

From Celebes there were 4 persons with a total worm count of 523; all of the worms were Necators. This means, of course, that the Ancylostome index was nil. The island of Celebes lies to the north, and is not a part of the chain of which Mid-Java, Madura, Bali, Lombok, and Timor are all units.

The Chinese treated in the jail were of three groups. In the first group—Chinese who were born in China but who had lived in Sumatra, where there was a low Ancylostome index—there were 13 cases with 838 worms, of which 255 were *A. duodenale.* The percentage of Ancylostomes, therefore, in this group was 30.4, which is a Chinese formula. In the second group—Chinese who were born in Mid-Java—there was only one case, with a total count of 57 worms, of which 11 were *A. duodenale.* The percentage of Ancylostomes in this group was, therefore, 19.3, which is a Mid-Java formula. In the third group—Chinese who were born in West Java—there was also but one case, whose worm count was 123, and only one worm was *A. duodenale.* The percentage of Ancylostomes was, therefore, only 0.8, which is a West Java formula.

It does not seem likely that the presence of *A. duodenale* in Mid-Java or East Java and in the eastern chain of islands, is at all due to the presence of Chinese, for the native stock greatly outnumbers them; moreover, the Java-born Chinese appear to evidence the formula of the natives of the locality, rather than the formula of the Chinese born in China.

It is quite possible that the Ancylostome index affords a clue to the ethnic origin or composition of the natives of Malaya, Java, and the other islands of the Netherlands Indies, and that a high Ancylostome formula indicates a large admixture of ethnic stocks from northern India or elsewhere. It will be remembered that centuries ago a considerable Hindu civilization flourished in Mid-Java, East Java, and Bali. Many of the Malays of the Federated Malay States claim Sumatra as their ancient home—indeed, it is often stated that it is the ancient home of the race—and the Ancylostome formulae of the natives of the two countries appear to be identical. (See Table 30, page 152.)

CHAPTER VII

FINDINGS CONCERNING MALARIA

Post-mortem Data. At the District Hospital at Kuala Lumpur a number of post-mortem examinations were made. It was found that the deaths due to malaria could be classified in two groups.

The first group was made up of those who suffered from acute pernicious malaria, in which cases myriads of plasmodia were found in the spleen, bone-marrow, or brain. There were 4 such cases, 3 of them Tamils and 1 a Chinese. This proportion corresponds with the distribution of these races on estates, and appears to represent the degree of exposure to infection from malaria to which they were subjected.

The second group consisted of those who suffered from chronic cachexia as the result of neglected, untreated malaria. While the individual cases of this group were not overwhelmed by large numbers of plasmodia, their blood-forming organs were gradually overpowered by small, but repeated dosages of the poison. Physical debility, incapacity for work, dysentery, malnutrition, and semi-starvation all contributed to hasten the development of a cachexia, and thus to bring about the coolie's death.

Inasmuch as cachexia occurs irrespective of the presence or absence of hookworms, it is probably safe to assume that these cases of the disease were due to malaria. Eleven cases of anemia were found to fall in this group. The number of worms recovered was not sufficient to cause any measurable degree of anemia, and it may therefore be assumed that the cause of death was long-continued exposure to malaria. From these post-mortem examinations, it would appear that hookworm disease was not a cause of death among the Tamils in the series.

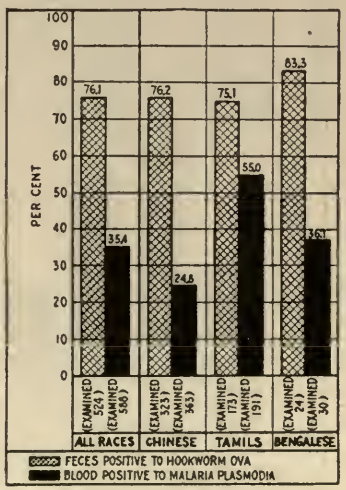

Fig. 57.—Results of fecal examinations for hookworm disease and blood examinations for malaria. District Hospital at Kuala Lumpur. By race. (Table 31)

Blood and Feces Examinations. Blood examinations were made on 588 patients at

the District Hospital at Kuala Lumpur, and 35.4 per cent were found positive for malaria parasites. Feces examinations were made on 524 patients and 76.2 per cent were found positive for hookworm ova. If the first stool specimen was found negative, a second specimen was obtained in a few days for another examination. Both blood and feces examinations were made for 522 of the total 588, including Chinese, Tamils, and Bengalese: 35.2 per cent proved to be positive for malaria, and 75.7 per cent proved to be positive for hookworm disease. Of the 64.8 per cent who were negative for malaria, 77.5 per cent were positive for hookworm disease. Of the 75.7 per cent who were positive for hookworm disease, 33.7 per cent were positive for malaria also. Of the 24.3 per cent who were negative for hookworm disease, 40.2 per cent were positive for malaria. It is thus evident that there was a high degree of malaria infection among those who came for treatment. (See Tables 31 and 32, pages 154 and 155.)

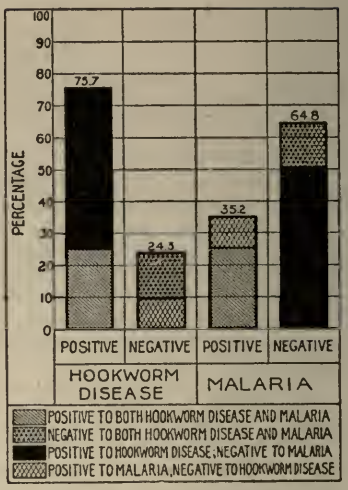

Fig. 58.—Rates of malaria and hookworm infection among Chinese, Tamil, and Bengalese patients; 522 cases at District Hospital, Kuala Lumpur. (Table 32)

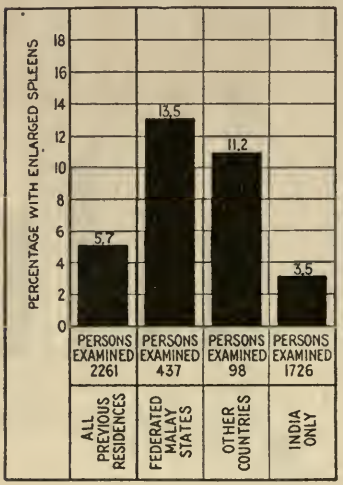

Fig. 59.—Correlation between intensity of enlarged spleens and previous residence in malarious locality. Spleen examinations at Port Swettenham. (Table 33)

Spleen Examinations at Port Swettenham. At Port Swettenham, 2,261 coolies were examined with reference to the possible presence or absence of spleen enlargement; a total of 130, or 5.7 per cent, enlarged spleens were found. Among the 1,726 persons who had never before been out of India, 60, or 3.5 per cent, had enlarged spleens. Among the 437 who had a record of previous residence in the Federated Malay

States, 59, or 13.5 per cent, had enlarged spleens. (See Table 33, page 156.) The size of the spleen was classified as being negative, palpable, one finger's breadth below the ribs, two fingers' breadth below the ribs, three fingers' breadth below the ribs, one hand's breadth below the ribs, or to the pelvis.

Additional examination of 150 children under 12 years of age proved that only 5 had enlarged spleens; thus the spleen rate among these children was 3.3 per cent.

Blood Examinations at Port Swettenham. Immigrants at Port Swettenham were examined for evidence of plasmodia in the blood. In a series of cases examined in 1915, the percentage of those found positive was 5.2 among the 189 who had never before been out of India, and 9.7 among those who had a history of previous residence in the Federated Malay States.

Among a series of cases examined in 1916 the parasite rate was found to be 3.4 per cent among those who had never been out of India before, and 12.5 per cent among those who had a history of previous residence in the Federated Malay States. The difference between the percentage in the 1916 series and that in the 1915 series is small, the percentage in the 1916 series being but 2 per cent less than that in the 1915 series. This difference may be due, at least in part, to a selection of cases with enlarged spleens in the 1915 series. (See Table 34, page 157.)

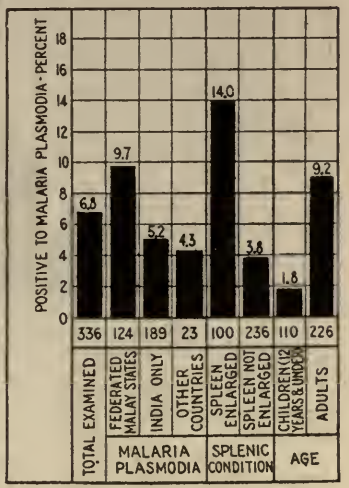

Fig. 60.—Correlation between malaria plasmodia and former residence, splenic condition, and age of patient. Blood examinations at Port Swettenham. 1915. (Table 34)

Blood Examinations in Malaya. In the course of the Commission's work, altogether 2,712 cases were examined for plasmodia in the blood: 677 at the quarantine camps at Port Swettenham and Singapore; 533 at two jails; 168 at six schools; 661 at two hospitals; 404 on 14 rubber estates; 162 at a tin mine; and 108 whose occupation was in connection with the public works department. Of this total number (i. e. 2,712), 463, or 17.1 per cent, were found positive for malaria parasites in the blood. Of the 463 mentioned, 82 showed subtertian rings alone; 56 showed subtertian rings and crescents; 74 showed crescents alone; 128 showed benign tertian alone; 109 showed quartan alone; 7 showed benign tertian and crescents; 3 showed quartan and crescents; 2 showed sub-

tertian and benign tertian; and 1 showed benign tertian and quartan. The decided preponderance of subtertian rings in the type of parasite was very noticeable. The large number of hospital cases tended to increase the malaria incidence of the total, but an examination of the separate groups showed that malaria was present, to a considerable degree, in cases not seeking hospital aid.

Malaria Survey at Port Swettenham. A comparison of the hemoglobin percentage of those who had never left India before, with those who had, as shown in Table 35, page 159, would seem to indicate that the degree of anemia found was due to residence in malarious countries—in other words, that the anemia found was malarial in origin.

A malaria survey was conducted in the neighborhood of the quarantine camp at Port Swettenham. Very few adult anophelines were caught in the camp, and of those that were caught only comparatively few were found within a radius of one-half mile, except in one particular locality. Some 150 females caught were dissected and, of these, two were found with sporozoites in the salivary glands.

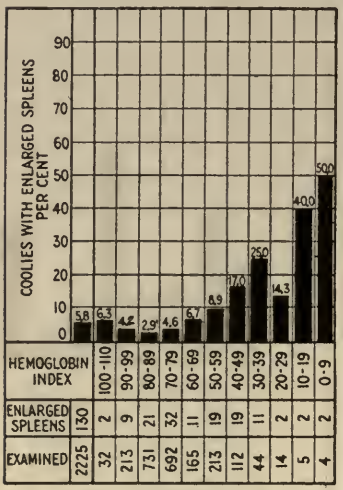

Fig. 61.—Correlation between hemoglobin rate and incidence of enlarged spleen. Examined for malaria at Port Swettenham. (Table 36)

The area between the nearest large breeding-place and the camp was inhabited, and the houses may have acted as a screen to the camp itself. At any rate, as far as *A. ludlowi* and *A. rossi* were concerned, two other large breeding-places of these species were located in the immediate vicinity of houses within the coolie lines. These probably proved a greater attraction to the anophelines than the camp, which was situated about half a mile away. The main breeding-place for *A. umbrosus* was found to be located about one and one-half miles from the camp at Port Swettenham, and many houses intervened between the breeding-place and the camp.

During the period of the malaria survey, 215 adult *A. umbrosus*, 36 *A. rossi*, 42 *A. ludlowi*, and 3 *A. kochi* were caught within a radius of approximately one-half mile from the camp. Within a radius of one mile from the camp, in the houses located in the different sections of Port Swettenham, 1,068 *A. umbrosus*, 176 *A. rossi*, 74 *A. ludlowi*, 63 *A. kochi*, 1 *A. tessellatus*, and 1 *A. kawari* were found.

From the evidence obtained during the survey it may be concluded that the possibility of malaria infection of coolies in the camp at Port Swettenham cannot be excluded. A comparison of the blood examination of groups with different lengths of residence in the camp, indicates that infection was taking place to a very small extent, if at all, at the time of the examination (August, 1916). The coolies who were examined at Port Swettenham during the period from September to December, 1915, showed little or no malaria when they were subsequently re-examined on healthful estates. From that fact it is safe to conclude that malaria infection of coolies at the camp at Port Swettenham occurred in a very small degree, if at all, during periods of examination of coolies there.

The fairly close relationship between the percentage of palpable spleens and the amount of anemia, indicated by the percentage of hemoglobin found, is shown in Table 36, page 160.

Malaria Survey on Estates. A malaria survey of each estate visited and of its immediate environment, was made during the course of investigations. One estate would be found to be located on a flat coastal plain with no uncleared jungles, no springs, and no hillside seepage, and therefore properly to be described as non-malarious. Another estate would be found to be decidedly hilly, with many springs and streams flowing from the hillsides. On such an estate, the seepage would create swamps and other propagation areas for mosquitoes. A locality like this would be properly described as a most malarious estate. In the course of the malaria survey such anophelines as were known carriers of malaria (e. g. *Anopheles maculatus*) were caught, and the females were dissected for evidence of infection. The malaria surveys on these several estates went to show that those in the interior, of a hilly nature like that described, where there was an absence of anti-malaria measures, were more malarious than those on the level coastal plains. The latter had been cleared of jungles and drained, and were therefore relatively free from malaria—except where propagation areas were found for *A. ludlowi*, which is a known carrier.

A group of 9 children on one estate was especially examined for hookworm disease, and it was found that among them 4.5 times as many worms were harbored in cases with as low an average of hemoglobin as 42.9 per cent as in cases which showed as high an average as 82.2 per cent. These cases, it should be explained, were found on the flatland estates where the incidence of malaria is low.

All the surveys, investigations, and treatments on the fourteen estates visited were made during the year 1916. These several estates were visited from 30 to 40 weeks after the examinations at Port Swettenham or at Singapore. The estates selected were, as has already been explained, those on which were to be found the coolies that had been either examined or treated at one of those ports. As many as possible of these coolies were re-examined for

evidence of exposure to malaria and for indications of changes in hemoglobin.

It was discovered that there was an average gain of 3.2 per cent hemoglobin among 234 coolies who entered the ports free from malaria but infected with hookworm disease. There was an average gain of 8.4 per cent in 162 cases that contracted no malaria after entering the Federated Malay States, and an average loss of 8.6 per cent in the 72 cases that did contract it. A combination of these last two figures would indicate that residence in the Federated Malay States should normally result in a gain of 17 per cent in the hemoglobin content. Normal expectancy of gain is probably attributable to the better wages and the better food which the workers enjoy in the country of their temporary adoption. It was perfectly clear that the tendency to gain hemoglobin was much affected by malaria. As between those who did, and those who did not, contract malaria during their period of residence in the Federated Malay States, there was a difference, in the average gain, of 17 per cent hemoglobin per case. As between those who did, and those who did not, contract hookworm infection during their residence in the Federated Malay States, there was a difference of 16.8 per cent average gain.

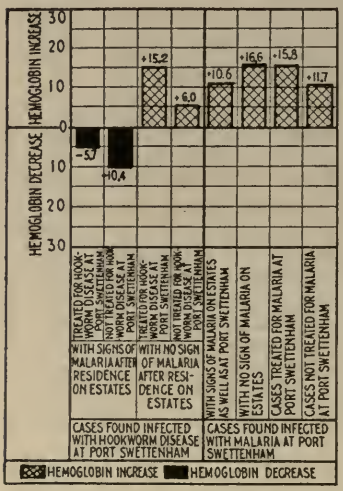

Fig. 62.—Gain or loss in hemoglobin after residence on estates. Re-examination, on estates, of coolies found free of malaria but infected with hookworm disease on arrival at Port Swettenham. (Tables 37 and 38)

Tables 37, 38, 39, and 40, pages 161 to 164, show the results of the findings of coolie re-examinations on the several estates. Table 37 gives the changes in hemoglobin (for all the estates that were visited) shown by coolies who were free from malaria but infected with hookworm disease on arrival at Port Swettenham.

First, as to the cases with evidence of malaria after arrival, Table 37 indicates that the 28 cases treated for hookworm at Port Swettenham showed an average loss of 5.7 per cent hemoglobin. The average loss of the 44 cases not treated at Port Swettenham was 10.4 per cent hemoglobin; the average loss for the total of 72 cases, irrespective of treatment, was 8.6 per cent hemoglobin. Therefore, the benefit due to treatment for hookworm in the malaria cases was

Fig. 63.—Estate children. Free of malaria (spleen and plasmodia negative) but with heavy hookworm infection. Although their physical appearance is good, their anemia is severe. Average number of hookworms harbored, 191, ranging from 27 to 402; average hemoglobin, 43, ranging from 12 to 66

Fig. 64.—Treatment squad in Sawah Besar (Batavia). Hookworm incidence, 80%; average worms, 19.6. These vigorous and more lightly infected town dwellers do not require treatment so urgently as the debilitated and more heavily infected agricultural populations

4.7 per cent, or the difference between the loss shown by the treated cases and that shown by the cases that were not treated.

Next, concerning the cases with no evidence of malaria after arrival, the table indicates that the 41 cases treated at Port Swettenham showed an average gain of 15.2 per cent hemoglobin. The average gain of the 121 cases not treated at Port Swettenham was 6 per cent hemoglobin; the average gain for the total of 162 cases, irrespective of treatment, was 8.4 per cent hemoglobin. Therefore, the benefit due to treatment in the non-malaria cases was 9.2 per cent, or the difference between the gain shown by the treated cases and that shown by the cases that were not treated.

As for the gain due to treatment, irrespective of malaria, Table 37 indicates that the 69 cases treated at Port Swettenham showed an average gain of 6.7 per cent hemoglobin. The average gain of the 165 cases not treated at Port Swettenham was 1.6 per cent hemoglobin. Therefore, the gain due to treatment was 5.1 per cent hemoglobin.

Table 38 gives a detailed account of the changes in hemoglobin, on all the estates that were visited, shown by the 19 coolies who had evidence of malaria on arrival at Port Swettenham. The table indicates that the average gain in hemoglobin of the total of 12 cases showing evidence of malaria on the estates as well as at Port Swettenham, was 10.6 per cent. The average gain in hemoglobin of the 7 cases without evidence of malaria on the estates, was 16.6 per cent; the average gain of the 5 cases that were treated at Port Swettenham was 15.8 per cent; the average gain of the 14 cases that were not treated at Port Swettenham was 11.7 per cent.

From these data it will be seen that the cases with evidence of malaria on arrival at Port Swettenham do not show the loss in hemoglobin shown by the cases arriving free from malaria. On the other hand, the cases that do not show evidence of malaria on the estates show a greater rise in hemoglobin than the cases that still show evidence of malaria. There is a slight benefit in treatment demonstrable in this series of cases as well as in the series which was shown to be free from malaria on arrival at Port Swettenham.

Table 39 shows what happened with regard to the hemoglobins of the twelve cases which were traced to estates, and which were shown to be free of both malaria and hookworm disease at Port Swettenham. The figures in the table indicate that all the cases showed a loss of hemo-

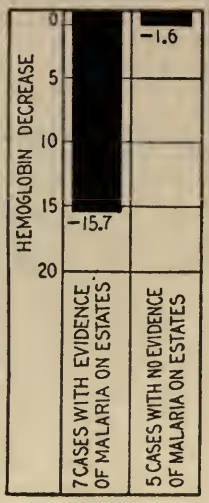

Fig. 65.—Gain or loss in hemoglobin after residence on estates. Re-examination of coolies free of malaria and hookworm disease on arrival at Port Swettenham. (Table 39)

globin even when they did not contract malaria. This was probably due to the fact that they became infected with hookworm disease, for the five cases that did not contract malaria went to a flatlands estate where hookworm disease was proved to be an important factor in causing debility.

Table 40 is a summary of the gains or losses in hemoglobin, with respect to malaria, of all the coolies found on each estate. When all the coolies found on an estate are taken as a single group, and the gross average change in hemoglobin is calculated—irrespective of treatment or of malaria—an important index is obtained showing the relative healthfulness of the estates. In the table, this gross average change in hemoglobin is compared with the number of cases showing evidence of malaria, and the estates are arranged in the order of the degree of change in hemoglobin found. The close relationship between the change in hemoglobin and the number of cases showing evidence of malaria, is a very important indication of the power of malaria as a factor in the production of anemia.

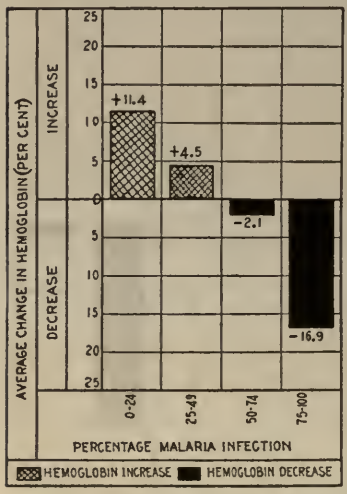

Fig. 66.—Re-examination of 267 coolies after residence on estates. Anemia and malaria. (Table 40)

Malaria in the Java Kampongs: Relation to Hookworm. In the course of the work in Java, the Commission undertook to ascertain what correspondence there was, if any, between malaria infection and the number of hookworms harbored. The Java kampongs, or compounds, may be divided into three classes with respect to malaria: (1) those highly malarious, (2) those free, or nearly free, from malaria; and (3) those with a few cases of malaria. Among patients residing in the first class of kampong, the spleen rates were high, while the worm counts were not. In Jaagpad, for example, the spleen rate was 91.9 (100 in the treatment squad), and the average number of hookworms harbored was 34.4. At Gebongelir the spleen rate was 97.0, and the average number of worms harbored was 46.7. At Endil the spleen rate was 87.6, and the average number of worms harbored was 51. In these dessas, or villages, it was apparently impossible to ascertain what influence either infection had on the other (malaria or hookworm) for practically the entire population was infected with both malaria and hookworm disease. Malaria always caused the greater amount of anemia, for the reason that the hookworm infections were usually mild.

Fig 67.—People of Batavia treated at Kampong Kramat. Spleen rate, 11.4%; plasmodia, negative; hookworm incidence, 100%; average number of worms per individual, 45

Fig. 68.—Two cases of hookworm infection in the highly malarious Kampong of Jaagpad, Java. The man had 54 worms; hemoglobin, 5%; spleen, 3 fb. below costal margin; blood contained malignant tertian plasmodia. The girl had 11 worms; hemoglobin, 67%; spleen, 2 fb. below umbilicus; blood showed polychromasia but no plasmodia at the time

Fig. 69.—A prolific breeding place in brackish water for the anophelines which spread malaria in the kampongs of Batavia near the sea

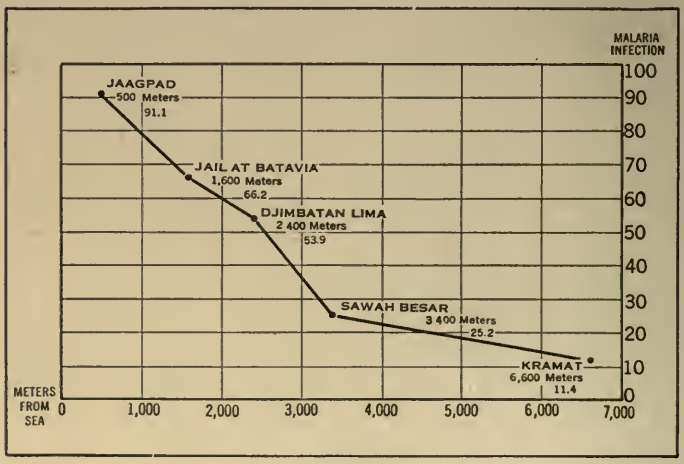

Fig. 70.—Correlation between incidence of malaria infection and distance from the sea. Spleen rates vary inversely with the distance

In Kalimaro, Kebasekan, and Krakal, on the other hand, there was little or no malaria, and the worm counts were high—Kalimaro 197.5 and Kebasekan 168.0 per person. These figures are about three or four times as high as those obtained in the malarious dessas, and the number of persons with palpable or enlarged spleens was too small for the data to afford any basis for an estimate as to the possible influence of one infection on the other.

The figures obtained in Batavia kampongs and in the jail, however, perhaps furnish some basis for comparison. The entire city may be regarded as urban, although, as explained elsewhere, the natives live in their kampongs within the city limits. In the city there is less soil pollution, however, than in the strictly rural districts. Near the sea there is severe malaria, but the incidence diminishes as the distance from the sea increases. It is therefore possible to compare the incidence of hookworm infection and of malaria in the four kampongs. The figures of such a comparison are shown in Table 41, page 165. It will be seen from this table that there is a considerably larger average number of worms in the group with enlarged spleens than in the negative-spleen group.

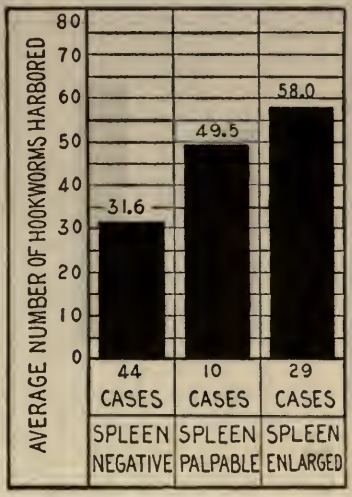

Fig. 71.—Relationship between splenic condition and number of hookworms harbored. Eighty-three persons treated for hookworm in kampongs of Java. (Table 41)

Malaria in Java Jail: Relation of Worms. Given, as positive evidences of malaria, the presence of plasmodia in the peripheral blood, enlarged spleens, or both, and as negative evidences the absence of plasmodia, and conditions showing the spleen neither enlarged nor palpable, the treated cases in Penal Institution No. 3 may be divided into the six following groups:

Group I—	Spleen	palpable—	Plasmodia	present
Group II—	"	enlarged—	"	present
Group III—	"	palpable—	"	absent
Group IV—	"	enlarged—	"	absent
Group V—	"	negative—	"	present
Group VI—	"	negative—	"	absent

Groups I, II, III, IV, and V contain all the cases with positive evidences of malaria at the time of examination. Group VI contains

the cases with negative evidences—that is, evidences showing active malaria to be absent—for it is understood that all the prisoners are constantly exposed to severe malaria infection. In the aggregate, however, only a certain limited number of men at any given time exhibit evidences of active malaria—plasmodia, fever, and spleen enlargement.

Reference to Table 42, page 166, will show that the average hemoglobin for the malarial groups was 66.9 per cent, and for the non-malarial group 81.2 per cent, while the average number of worms in the former groups was 98.4 and in the latter group 54.8. Thus it would appear that in this jail there was a correlation between the presence of malaria and the number of worms.

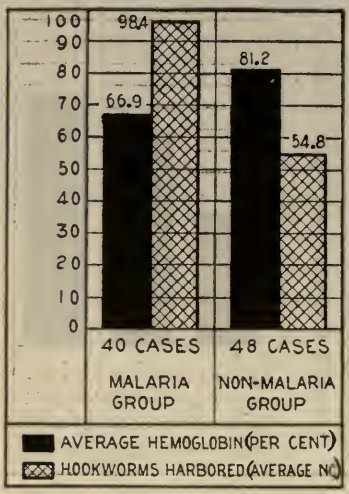

Fig. 72.—Correlation between presence of malaria and number of hookworms harbored. Eighty-eight cases in Java jail. (Table 42)

It must be remembered that the men were constantly exposed to malaria infection and were in a state of inconstant flux with regard to it—men suffering from the disease one month being apparently free from it the next. This condition was demonstrated at the jail by the condition of men whose spleen and blood were negative, but who succumbed to malaria within a few days after admission to the ward, and also by the diminution in size of spleens in malaria cases at the time of re-examination after several weeks.

It is also demonstrably true that the prisoners were not acquiring new hookworm infections; their respective complements of worms were brought in with them. In fact, there was a tendency for them to lose worms the longer they stayed in prison. The more severe cases of hookworm infection, as well as some other hookworm cases, were probably weeded out by treatment, for about 10 per cent of the men in the treatment squads had been treated with chenopodium in the hospital adjoining the jail.

Under these circumstances, the underlying causes that have led to a correlation between low worm counts and negative spleens are not known. Perhaps a better idea of the situation may be obtained if the cases are analyzed with special regard to the relation of worms to plasmodia, as is done in Table 43, page 167.

The following points should be noted: (1) the higher average worm counts were encountered in the groups in which, at the time of exami-

nation, plasmodia were absent but in which spleens were either palpable or enlarged; (2) lower average worm counts were found when plasmodia were associated with enlarged or palpable spleens; (3) the lowest average worm counts were found when plasmodia were absent and the spleens were negative; (4) the anemia is correlated, not with the presence or absence of plasmodia, but with a palpable or enlarged spleen.

In one of the squads the examination of blood for plasmodia was not made, but there were eighteen cases which may be analyzed with regard to splenic enlargement, number of worms, hemoglobin, and length of time in prison.

In Table 44, page 168, which includes these eighteen cases in addition to the other treatment

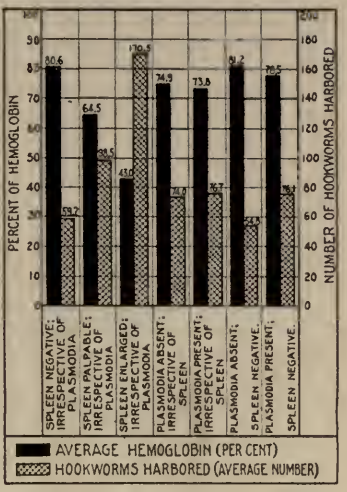

Fig. 73.—Relationship between number of hookworms harbored and presence or absence of malaria plasmodia. Eighty-eight cases in Java jail. (Table 43)

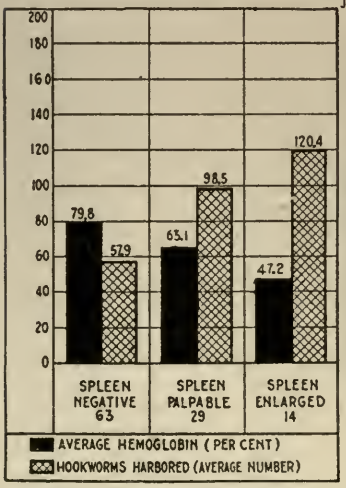

Fig. 74.—Correlation between splenic condition and number of hookworms harbored. One hundred six cases in Java jail. (Table 44)

squads, it will be seen that there is a very marked positive correlation between enlarged spleens and number of worms, and that, as regards this correlation, the palpable spleen occupies a place intermediate between the negative spleen and the enlarged spleen.

There seems, however, to be little or no correlation between plasmodia and worms, when cases are taken irrespective of the condition of the spleen. The average number of worms associated with plasmodia was 76.7 and the number of patients with plasmodia absent at the time of examination was 74. (See Table 43.) In the negative-spleen group, however, there was a positive correlation between plasmodia and

worms. Anemia was also positively correlated with worms and splenic enlargement.

The degree of splenic enlargement increased with the duration of exposure to malaria infection, and in the negative-spleen group the presence of plasmodia was negatively correlated with length of exposure to malaria. It is to be inferred, therefore, (1) that plasmodia are more apt to be demonstrated in the earlier periods of jail residence, (2) that splenic enlargement occurs with greater frequency in the later periods of residence, and (3) that the men receive in the jail more malaria than they bring in.

This is borne out by the observation that 92 prisoners confined from 1 to 3 months had an average hemoglobin of 83.5 per cent, while the average of

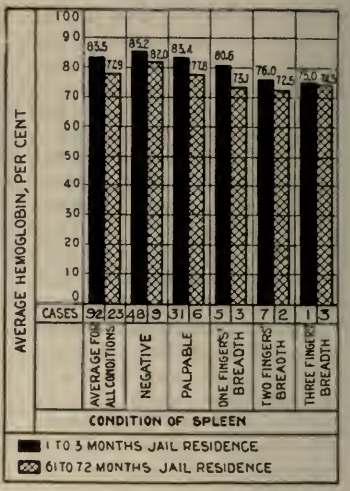

Fig. 75.—Hemoglobin rate and degree of splenic enlargement in relation to length of jail residence; 115 cases in treatment squads in Java jail. (Table 45)

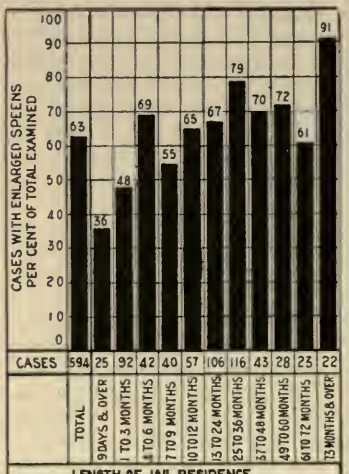

Fig. 76.—Splenic enlargement in relation to length of jail residence; 594 cases in Java jail. (Table 46)

the total (594) was 77.1 per cent. (See Table 45, page 169.) Furthermore, of 25 men who had been in the jail for periods of nine days and under, and who received examination, 16 had negative, 4 palpable, and 5 enlarged spleens—a spleen rate of 36. This splenic enlargement must have been brought in with them.

The frequency of splenic enlargement increases markedly during the first 6 months of jail residence. (See Table 46, page 170.)

The correspondence between splenic enlargement and high average worm count, so far as this jail is concerned, may be explained by the fact that men free from malaria come into the jail from regions where there is little or no malaria, but where

there is considerable hookworm infection. The men with high worm counts and anemia might be more liable, after malaria infection, to acquire and retain a degree of splenic enlargement. Here it would seem possible that hookworm infection with anemia might render a person more susceptible to malignant influences of malaria —in the case of those free from malaria and harboring a large number of worms, who take up residence in a malarious locality and become infected with malaria. But we should not eliminate, in considering the series, the possibility of cases occurring which, previous to entrance, already had a large complement of worms, owing in part to the lowering of resistance to hookworm re-infection by attacks of malaria.

Control Investigations in the Fiji Islands. It was clear to the Commission that, for the purpose of control facts and figures, it would be necessary to study conditions in some community known to be free from malaria in an endemic form. While it is true that hookworm infection is universal in the tropics, malaria is not co-extensive with it. For instance, Barbados is free of malaria; the same is probably true with respect to some of the estates on the flatlands of the Federated Malay States, and some districts in Java and Sumatra. But it was deemed desirable, in order to eliminate all doubt, to make the control investigations in some of those islands of the Pacific which were known to be entirely free from endemic malaria. This condition prevails among the islands of the Fiji Archipelago. It will be remembered that the investigation in the Federated Malay States had been made among the coolies from South India. Therefore, inasmuch as many Indians, both free and indentured, were to be found in the Fiji Islands, the conclusion was reached by the Commission that no better place for making the control studies could be found.

The observations of the Commission were confined to the largest island in the Archipelago, Viti Levu—to territory on the south side of this island and, for the most part, in and around the town of Nausori, and among the coolies living on the plantations along the Rewa River. Both the native Fijians and the Indians examined here were apparently in good physical condition. The indentured Indians were in rather better condition than the free, or time-expired, coolies.

The work was begun with a preliminary malaria survey. Groups were assembled and clinically examined for evidence of enlargement of the spleen and for clear indications as to hemoglobin content. Like groups were then carefully tested for hemoglobin percentages, and blood examinations were made for the purpose of discovering any direct evidence of malaria. This work was conducted as follows: among the persons in the Colonial jail at Suva; among the indentured Indians working in the sugar factory at Nausori; among both the indentured and the free Indian shopkeepers and artisans working in the village of Nausori; among the Fijian

youths, practically all of whom were either sons of chiefs or else from some of the other high-caste families, attending the Queen Victoria School; among Fijian men, women, and children in the villages of Nausori and Vanimora (both river towns); among Fijian men, women, and children in the village of Nasaqo (which is a mountain town); and among European men, women, and children in the village of Nausori.

Of the 529 who were examined for indications of malaria plasmodia, 297 were Indians, 158 were Fijians, and the rest were Europeans—half-castes and Polynesians of all ages and both sexes. In the examinations for indication of blood parasites—plasmodia and filaria—thick film stains, obtained by modification of Hasting's stain, were employed. None of those examined were found to be positive for plasmodia and, respecting all those examined for enlarged spleens, only 5 palpable spleens were found among 57 patients examined at the Suva Hospital, 1 among the 64 boys examined at the Queen Victoria School, and 6 (all in the case of North Indians) among the 885 Indians and Fijians who were examined on the plantations along the Rewa River, near Nausori and Nasaqo. Careful search was made near Suva, Nausori, and Nasaqo for anopheline larvae, but none were found.

Clearly, therefore, malaria was not found endemic in the districts visited by the Commission, and the medical history of the people—as drawn from the reports of the Chief Medical Officer and from conversation with medical practitioners, planters, and officials—together with the absence of anopheles, convinced the Commission that the island was entirely free from this disease in an endemic form. Paroxysms of malaria are said to attack indentured coolies occasionally during the first year or two after arrival from India, but no evidences of acute or chronic malaria were found in any of the more recently arrived indentured coolies examined by the Commission. Nor was a history of dysentery obtained in more than two or three cases. The anemia observed may therefore be properly attributed to the effect of hookworm infection, intensified more or less in certain classes by an insufficiency of food.

CHAPTER VIII

FINDINGS CONCERNING ANEMIA

Hemoglobin Standards in Relation to Race, Age, and Sex. The principal question to which the Commission was expected to find an answer was, "To what degree is Uncinaria infection a menace to the health and working efficiency of the people of Malay?" In order to answer this question it was necessary to give some relative weight or value to hookworm infection, associated as it nearly always is, with malaria. It would be necessary to find out in any given community the degree of anemia due to hookworm infection. The damage done by malaria — as indeed also the benefit derived from treatment for hookworm infection—is expressed in terms of average loss or gain of hemoglobin per individual. It is quite clear, then, that if we wish to state to what degree hookworm infection is a menace on A. B. estate, the factor may be best expressed in terms of lost hemoglobin per individual. But if we wish to state to what degree it is a menace on X. Y. estate, where there is also severe malaria, it is a problem to know how it shall be estimated and expressed.

Individual cases of infection, it was found, could not be properly compared on account of the unknown factor of individual resistance or perfection of defense. But when all the cases were bulked and averaged it was observed that there was some correlation between degrees of anemia and numbers of worms, and this fact led to the conclusion that it would be possible to work out a factor which would express, if only crudely, the amount of anemia caused by a given number of worms. However, it was not so simple a matter to work out this factor, as several difficulties were met which had first to be overcome. In the first place, it was found impossible to establish a single standard of hemoglobin for a total population. A fact not generally recognized is that the hemoglobin differs considerably in the two sexes and in the different periods of life, and yet this disparity is so marked that for purposes of exact comparison groups must be considered. Examination of large numbers of apparently normal people disclosed considerable variation from the average which exists through all the decades of life and exhibits a marked degree of consistency.

A fairly large number of individuals were examined in an effort to ascertain the hemoglobin percentages of the sexes and of various races at different periods of life. Many interesting facts were brought out by these examinations. It was found, for instance, that age influences the hemoglobin values, not merely during adolescence but during the entire period of life, so that different values must be assigned to each decade. To illustrate: it was found among the kampong people that the highest point of the wave was reached during the third

decade, the 20–30 years period. The lower values began to show themselves in the next decade. After the fiftieth year a very decided drop was found to occur, reaching at times the values seen in early childhood.

The examinations conducted among the Tamil coolies at Port Swettenham, among the Chinese coolies at St. John's Island (Singapore), and among the natives of Java proved conclusively that there was a very marked difference between the hemoglobin values of men and the hemoglobin values of women. At Port Swettenham, with the Dare's instrument, hemoglobin determinations were made on 2,261 Tamil coolies. Of the 1,659 men thus examined, the majority showed a hemoglobin average of between 80 and 89 per cent, and the majority of the 452 women, and 150 children under 12, examined showed a hemoglobin percentage of between 70 and 79. In other words, the average hemoglobin among the men was found to be about 10 per cent higher than among the women.

It was found that the effect of pregnancy on the hemoglobin was very striking, and seemed to be more noticeable in the later months. Again and again this reduction in hemoglobin value due to pregnancy was encountered, oftentimes amounting to as much as 15 per cent below that of the normal non-pregnant women of the kampong. This is probably attributable to hydremic plethora, a condition which, although normally encountered in pregnant women, is also probably a frequent occurrence after puberty in non-pregnant females whose hematopoietic system is overtaxed. The reason for this explanation is the fact that a number of women were found who were suffering from anemia, and in whom no other cause of anemia could be elicited. Malaria was absent at the time of examination, and the number of hookworms was too inconsiderable to be assigned as a cause. Observations would seem to indicate that females are very much more unstable as regards their reaction to an anemia-producing cause. (See also section "Greater Severity of Anemia in Women," page 115.) The fact that a very large proportion of the women were found pregnant added considerably to the difficulties of the Commission in determining the hemoglobin standard of women.

In the course of its investigation the Commission found in Java a place in which there was no malaria. Anthelmintic treatment of a representative group of the dessa people disclosed the fact that very few worms were harbored by them. The incidence of infection as determined by treatment was 52 per cent, and the average number of worms per individual was only 6.3. Thirteen men whose ages ranged from 17 to 50 showed an average hemoglobin content of 99.3 per cent. Nineteen children whose ages ranged from 5 to 14 showed an average hemoglobin content of 90.1 per cent. This group of people, who lived and worked at an altitude of 3,600 feet, was relatively the freest from malaria or hookworm infection of any people investigated anywhere. Four of the men treated were found to have hemoglobin percentages of 96, 98, 101, and 104, respectively. Were it not

Fig. 77.—Types of natives in treatment squad at Tjimatjan, Java. Living at an altitude of 3,600 feet, free from malaria, and have very little hookworm infection. A fine sturdy lot. Spleen and parasite rate, nil; hookworm incidence, 52%; average hookworms, 6

Fig. 78.—A vigorous dessa man carrying his plow on his shoulders to the fields. Hookworm infection in the district very light

Fig. 79.—In the squad were seven cases of hookworm infection with anemia, from Karangsari and Winosari. Total worm count, 3,117; average, 445; spleen rate, 14.2%; average hemoglobin, 41.8%; plasmodia, nil. Mass hookworm treatment of entire population in these regions is most urgently required

Fig. 80.—Treatment squad, Jaagpad, Batavia.

Hemoglobin	39	33	55	59
Spleen	palpable	2fb. below umbilicus	pelvis	4fb. below umbilicus
Worms	10	63	51	10

Note splenomegaly in the case of 2, 3, and 4, whose anemia is due chiefly to malaria, and not to hookworm infection

for the fact that these people were living at so high an altitude, to which fact their higher hemoglobins could conceivably be attributed, they might well be regarded as a satisfactory group from which to derive an average hemoglobin standard.

Control determinations of hemoglobins of the members of the Commission were made at the time, and found to register several degrees lower than those of the natives infected. The average hemoglobin of the members of the investigating party was found to be 87 per cent, which is what it had registered at sea level on several previous occasions. It was therefore thought unwise to use a high altitude index as a standard with which to compare people living at or near sea level.

It was felt by the Commission to be highly desirable, if possible, to derive a number based on actual determinations with instruments, rather than to take an arbitrary number as the standard of the normal hemoglobin content. This of course means that in order to determine, with any degree of accuracy, what is the normal average hemoglobin of a mixed population, nearly all of whom are infected with hookworm disease, it is necessary first to separate the people into sex and age groups and determine the hemoglobins of these groups.

Therefore, in the Commission's investigation of the subject in the Java kampongs that were free from malaria, the people were divided into sex and age groups. A group from a kampong highly infected with hookworm disease, and presenting cases of anemia, was compared with a corresponding group from a kampong more lightly infected. It was observed in the kampongs where there was much malaria that there was no close correspondence between the degree of anemia, which was usually severe, and the number of worms harbored by the people. On the other hand, in kampongs free or nearly free from evidence of malaria a high positive correlation was observed between the degree of anemia and the number of worms. It should probably be added that while this was true of averages it was not necessarily true of all individual cases. A standard hemoglobin for each group was determined from the data obtained.

The problem, as presented in Fig. 81 may be stated as follows: the average hemoglobin of the boys in Kampong Kalimaro is 71.5 per

	KALIMARO	BATAVIA
Age in years	9.7	9.2
Number of cases	9.	14.
Normal average hemoglobin of boys	85.0%	85.0%
Average hemoglobin of boys treated in the kampongs	71.5%	82.3%
Calculated loss due to hookworms	13.5%	2.7%
Average number of worms harbored	106.0	20.7
Calculated number of worms required to produce a loss of 1 per cent hemoglobin	7.9	7.7
Loss due to hookworms	85.0-71.5=13.5%	85.0-82.3=2.7%
Number of worms required to produce 1% decrease	$\frac{106}{13.5}=7.9$	$\frac{20.7}{2.7}=7.7$

Fig. 81.—Loss of hemoglobin caused by hookworms harbored. Based on examinations of 23 boys living in 2 Java kampongs

cent and their average worm count is 106. The average hemoglobin of boys in Kampong Batavia is 82.3 per cent, and their average worm count is 20.7. What should be the hemoglobin average of a similar sex and age group whose worm count is zero? There were sufficient data for working this out for men, women, and boys. The standard for men was worked out, first, by plotting the average hemoglobin and the average number of worms obtained from the men of Kalimaro; next, by plotting the same for the men of Kebasekan (Fig. 82).

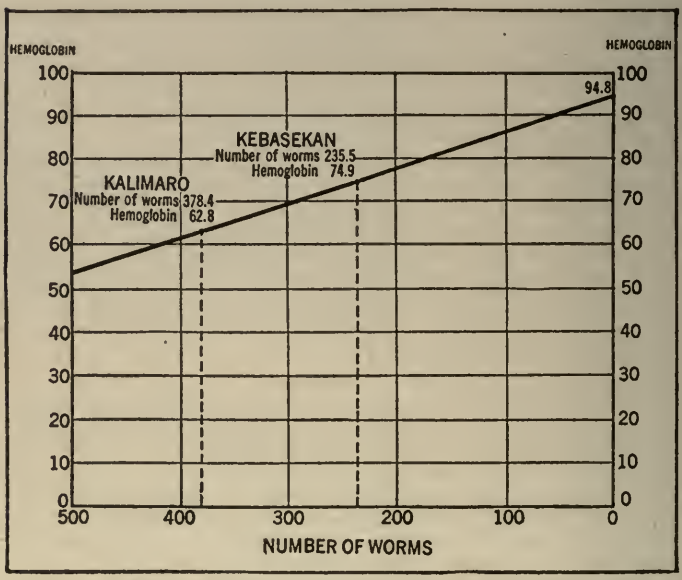

Fig. 82.—Method of determining the normal average hemoglobin

A line from the first through the second intersected the line of no worms at the point represented by approximately 95.0 (i. e. 94.8) per cent hemoglobin. This is what we should expect to find as being the average normal hemoglobin of men in general. Fig. 83, page 89, presents in more detail the data regarding men in two Java kampongs.

As a basis for discussion we shall use 95.0 per cent as the average normal hemoglobin for men, ascertained by the instrument that was used. This calculated percentage of hemoglobin (94.8 per cent) was rarely or never found among the kampong men, for there were several causes tending to lower the hemoglobin content. It was nearly approached, however, in a group of well-fed men in the Stadsverband, Batavia. This was a group of beriberics, Chinese and Malays

	KEBASEKAN	KALIMARO
Number of cases	10.	9.
Calculated normal average hemoglobin	95.0%	95.0%
Average hemoglobin of men treated in the kampongs	74.9%	62.8%
Calculated loss due to hookworms	20.1%	32.2%
Average number of worms harbored	235.5	378.4
Calculated number of worms required to produce a loss of 1 per cent hemoglobin	11.7	11.8
Loss due to hookworms	95.0-74.9=20.1%	95.0-62.8=32.2%
Number of worms required to produce 1% decrease	$\frac{235.5}{20.1}=11.7$	$\frac{378.4}{32.2}=11.8$

Fig. 83.—Loss of hemoglobin caused by hookworms harbored. Based on examinations of 19 men living in 2 Java kampongs

at one end of a ward. The men were all well nourished, but on account of physical disability were unable to work. They were living in a screened ward, free from malaria, and were able to maintain high hemoglobins. The range of hemoglobin was 85 to 97 per cent, and the average for the group of 9 men was 92.3 per cent.

In working out the standard for the women a marked difficulty was encountered. The cases of the women at Kebasekan exhibited a very definite positive correlation between the amount of anemia and the number of worms, as is seen below:

Percentage of hemoglobin	40,	46,	60,	69,	84,	85,	86,	88
Number of worms	433,	261,	400,	31,	31,	38,	97,	9

The average hemoglobin was 69.7 per cent, and the average number of worms was 163.3. The average age of the women was 32.2 years, the range being 18, 18, 30, 32, 35, 40, 40, 50. On the other hand, the women of Kalimaro were all under 22 years, the average being 20.5 years, and the range 18, 20, 20, 21, 21, 22, 22. Of the seven, 4 were nursing infants at the time and the 2 with the lowest hemoglobins were pregnant. It had already been found that the pregnant women might have hemoglobin values of 15 per cent less than the non-pregnant women of the kampong. It was preferred, therefore, not to estimate by this group of women in calculating the standard. Instead, the group from Kramat and Kebasekan was used.

	Kebasekan	*Kramat*	*Calculated for no worms*
Number of cases	8	5	...
Average hemoglobin	69.7	85.6	86.5
Average worms	163.3	9.0	0.0

The standard for boys was derived from Kalimaro, Kebasekan, and Batavia.

The standard 85 per cent for boys will be used, as representing the normal average hemoglobin percentage for this group.

There were no cases of anemia among the girls, and no marked differences in the worm counts or in the hemoglobin values. On this account we shall use the standard derived for boys.

In the case of women and boys, Kampong Kramat was used for comparison with Kebasekan and Kalimaro. The worm counts were very low in Kramat, and the loss of hemoglobin may have been compensated. In that case 85.6 per cent for women and 82.3 per cent for boys should be used as a standard. In the case of men the standard is derived from two groups having definite but different amounts of measurable anemia.

Anemia Caused by Hookworm and Malaria. Malaria is very common in the tropics. Indeed, malaria and hookworm infection are so frequently complicated that the anemia resulting from the one has often been attributed to the activities of the other. On the whole, severe anemia due to hookworm disease is less common than severe anemia due to malaria. It would, of course, be very desirable to express numerically the relative importance of malaria and hookworm infection in the causation of anemia, and their respective places in vital statistics. But unfortunately the subject is so complex that it is not possible to do more than record the unanimous conviction of the Commission that in the Federated Malay States malaria is the more serious infection, and that it causes far more anemia, debility, and death than hookworm disease.

In the Federated Malay States so much malaria was found that it was quite hopeless to estimate the relative importance of the two infections, especially because of the impossibility of entirely eliminating, either in individuals or in groups of cases, recent and past malarial influences. In Java, on the other hand, while there were places with severe malaria and little hookworm infection, there were other places with severe hookworm infection and little or no malaria. It is true that the number of cases in the series studied was small, but the absence of malaria was so nearly complete that the data have been used in an attempt to ascertain the relative values of the two infections in Java—that is, in places where the malaria is as severe as it is in many places in the Federated Malay States.

The data obtained, and here presented, indicated that in regions where there is hookworm infection uncomplicated by malaria, persons may harbor a considerable number of worms without showing any measurable degree of anemia. In the same community, groups of persons were sometimes found with a large number of worms and a definitely measurable amount of anemia; other groups, also, were found consisting of persons with anemia of a more severe grade, and with a still larger number of worms. In the higher grades of hookworm infection, when the numbers of worms mounted into the hundreds, it is to be noted, in comparing the two groups—whose respective hemoglobins differed by several degrees—that a given number of worms caused a certain degree of anemia. The worms apparently caused a loss of hemoglobin at such a rate and in such an amount that the host was unable to counterbalance the loss, and the greater the number of worms the less able was he to compensate for losses. Thus, in the case of the highest worm count the loss of a

degree of hemoglobin is apparently caused by fewer worms than in the case of the medium grades of worm counts.

If losses of hemoglobin are going on in the cases with moderate and high worm counts, which are measurable, it may be safely assumed that in lighter and lighter cases of infection, the gradations of losses are also going on, correspondingly lighter and lighter, but that they are counterbalanced, so far as we are able to measure them.

There are reasons for believing that in places like Mid-Java, about 8 worms in a boy and 12 worms in a man may cause a hemoglobin reduction of one degree. This can be measured in places where the average worm counts of the boys are over 100 and the average worm counts of the men are over 200. Where the average number of worms harbored is very high, the worm factor, as worked out here, could be applied. Where the worm counts are small, the cases are few and it is not possible to say how much measurable loss is suffered by the persons with a few worms. This is due to the fact that there is little or no resultant anemia, to the small number of cases in the series, and to the normal range of hemoglobin in persons free from malaria and hookworm disease.

The effect of the complement of worms in causing anemia is counterbalanced when the reserve powers are not interfered with. But if the reserve powers are weakened and broken down through malaria, malnutrition, under-feeding, exhausting labor, and other causes, the losses of blood due to the activities of the hookworms might not altogether be made up, and would probably cause anemia. It would be difficult to measure the amount in the presence of another cause, but when the reserve powers are entirely broken down—and this apparently is what happens in severe cases of malarial cachexia—one would expect hookworms to produce, in relation to number, the same amount of anemia here as when larger numbers are harbored, causing measurable anemia.

On the average, a moderate number of worms, say 250, cause measurable losses of hemoglobin, and it is reasonable to assume that 50 worms would cause one-fifth as much, whether their effect was counterbalanced or not.

Hookworm-Anemia Factor. In the presentation of this section dealing with an attempt to assign a definite value to each infection as a cause of anemia, the expression has taken a numerical form but the numbers should be regarded only as relative and approximate, for they are based on small numbers of cases. This cannot be emphasized too strongly. Efforts were made to get representative groups of the population, with hemoglobin determination and physical examination as the basis, but it is likely that, if the places were re-visited, while essentially the same results would be obtained, the factor would not be identical. The absence of the complicating malaria factor is nearly complete in some of the dessas, so that the data are presented with the reservation that the figures must not be taken too literally.

The worm-anemia factor is based purely on Java findings. In estimating the losses of hemoglobin in Penal Institution No. 3, it was observed that the losses due to hookworm disease were markedly apparent only after the 100-worm group had been passed. In the kampong series there is a similar fall in values beyond the 100-worm group, but there is also a progressive fall in hemoglobin values from the 100-worm group to the 0-worm group. In view of the positive correlation of worms to anemia beyond the 100-worm group, it is difficult to account for the apparent discrepancy in the group with the smaller numbers of worms, unless it is due to small numbers of exceptional cases. There is some doubt, therefore, in dealing with the series, as to the effect of smaller numbers of worms in causing anemia. As a matter of fact, in rural districts it was unusual to find a small number of worms in persons living under conditions in which they were free from malaria. This, however, may not have been due to any influence of malaria, but to greater liability of acquiring hookworm infection in the latter places, as at Kebasekan and Kalimaro. (See Table 47, page 171.)

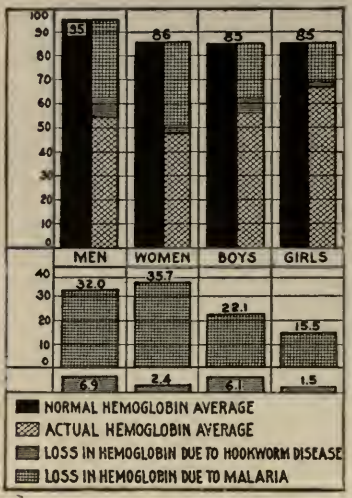

Fig. 84.—Hookworm infection and malaria as anemia-producing factors in dessas of Gebongelir, Java. By sex and age groups. (Table 47)

In Sawah Besar and Kramat there was little or no evidence of malaria among the majority of the people, and here the presence of a few worms was correlated with hemoglobin values a little below what was calculated for the normal, the indications being that there might be small losses of hemoglobin and slight anemia due to small numbers of worms. The number of cases was small, however, and in view of the range in hemoglobin among persons free from malaria or hookworm disease, and the effect of other causes of anemia, the Commission was led to believe that the factor may be of use only when the number of worms is large, or in places where there is intense malaria and when all the worms are probably causing anemia. The factor is also an expression of the number of worms required to cause a unit amount of loss of hemoglobin in a population, irrespective of whether it represents total loss or loss that is partly or fully compensated. Some idea of the number of worms required to cause a loss of 1 per cent of hemoglobin may be obtained by dividing the average loss of hemo-

globin in any age or sex group into the average number of worms actually found to be harbored by the group. This method is illustrated in Figs. 81 and 83. Here it is seen that the calculated number of worms required to cause a loss of 1 per cent hemoglobin in a boy is 7 to 8, while in a man it is 11 to 12.

By means of these factors it is possible to calculate the amount of anemia caused in a district by hookworm, and the amount of anemia caused by malaria can also be estimated by difference. This was done in Gebongelir after a representative group of the population had been examined, treated, and their expelled worms counted. (See Table 47, page 171.) In this calculation it is assumed that only two causes of anemia are operative, and it is estimated that among the men 6.9 per cent of their anemia is due to hookworm and 32.0 per cent to malaria.

Hard labor and sub-nutrition are undoubtedly strong factors in accentuating the anemia of people suffering from either malaria or hookworm. An attempt to estimate the effect of sub-nutrition was made among prisoners in the Batavia jail, Java. (See Table 49, page 173.)

The effect of hard labor on prisoners was observed in Java, and an estimate of its effect on the hemoglobin percentage was made. In the jail, hookworm treatment was administered to some 109 men, and a re-estimation of their hemoglobin was made 3 months later. It was discouraging to find that the men had gained only 2.4 per cent hemoglobin per man. This was found to be due to the combination of continuous malaria re-infection and hard labor on a prison diet. An estimate was made of the amount of anemia caused by the three chief factors, hard labor, malaria, and hookworm infection.

Given the assumed normal calculated hemoglobin of men as 95, the loss due to hard labor, 8.0, or the difference between 85.3 and 77.3 (i. e. the hemoglobin of the clerks and of the prisoners at hard labor) is subtracted, the balance being 87, which should include the losses due to both hookworm and malaria.

The average hemoglobin of men with malaria who were free

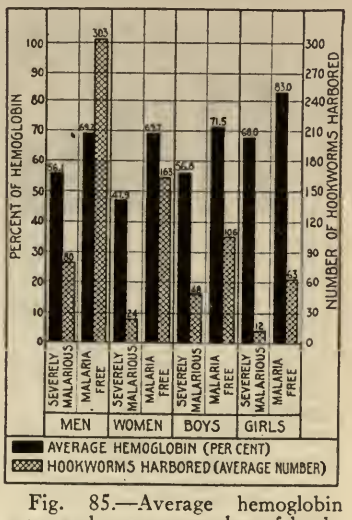

Fig. 85.—Average hemoglobin rates and average number of hookworms harbored in one malarious and two non-malarious dessas of Java. By sex and age groups. (Table 48)

from hookworm is 76.5; this subtracted from 87 should give the amount of anemia due to malaria, or 10.5 per cent. The average hemoglobin in each worm group should now be 76.5 per cent if there were no hookworm infection; but the average hemoglobin of each group, by actual determination, shows marked reduction in the higher worm groups.

The amount due to the activities of the worms may be calculated by subtracting the actual averages from 76.5, leaving a balance of 0 in the "0-worm" group, 1.2 per cent in the "1 to 100" worm group, 13.8 per cent in the "101 to 200" worm group, 9.1 per cent in the "201 to 300" worm group, 26.5 per cent in the "301 to 400" worm group, and 39 per cent in the "401 and over" group.

Or if the 109 treated cases are taken, it is assumed that their normal hemoglobin should be.....95.0%

Deducting the average hemoglobin of all the treated groups..69.2

Balance = loss due to various causes.....25.8%

Deducting the loss probably due to hard labor, or the difference between the average hemoglobin of 30 clerks and the average hemoglobin of prisoners at hard labor (85.3 − 77.3), = 8.0

Balance.....17.8%

The average number of worms in the group was 79.5; when this is divided by the factor 11.7 (see Fig. 83) the amount of anemia due to hookworm appears to be 79.5 ÷ 11.7, or..... 6.8

Balance = the loss due to malaria.....11.0%

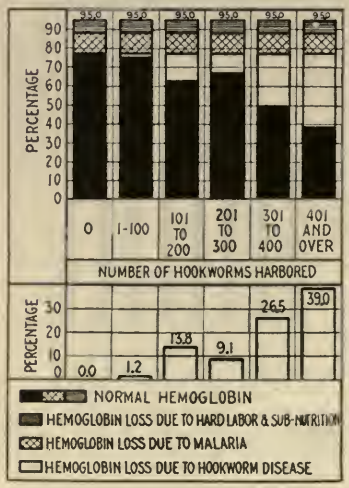

Fig. 86.—Respective losses in hemoglobin from hard labor and sub-nutrition, malaria, and hookworm infection. Prisoners in Batavia jail, Java. (Table 49)

The effect of hard labor was estimated by comparing the hemoglobin of 30 clerks at light occupation with the hemoglobin of the other prisoners who were at hard labor. The diet was exactly the same in quality and quantity for each class, and each was infected with malaria to the same extent. The hemoglobin of the clerks was 8.0 per cent higher than that of the men at hard labor.

The loss due to malaria was estimated by taking the average hemoglobin of six men not infected with hookworm and using this for comparison with the others. (See Table 49, page 173.)

In some of the dessas of Java an effort was made to determine the percentage of that loss which could be fairly attributed to malaria, and also to determine the percentage which could be reasonably attributed to hookworm disease. Results in a given malarious dessa were analyzed, and an attempt was made to show how much anemia was due to malaria and how much was due to hookworm infection.

Gebongelir, a fishing village on the north coast of Java, presents a striking example of a combination of hookworm infection and malaria as factors in producing anemia. (See Table 47, page 171.) The spleen rate here was 97 and the parasite rate was 29. Instead of combining the gross average hemoglobin values of the people of this malarious dessa with those of another dessa, free from malaria, it seemed best to compare the hemoglobins in respective age and sex groups. This comparison showed that among the men malaria caused about five times as much anemia as hookworm infection; among the boys about three and one-half times as much; among the women, and perhaps among the girls, about fourteen times as much.

The comparison of the calculated losses due to malaria in Gebongelir with the calculated losses due to hookworm infection in Kebasekan and Kalimaro (see Table 47) gives one a fairly good idea of the damage done by malaria in a typical dessa in the densely populated flatlands of Mid-Java. The calculated normal hemoglobin of the men at Gebongelir was 95, of the women 86, of the boys 85, and of the girls 85. The calculated loss due to malaria in this dessa was, among the men 32.0, among the women 35.7, among the boys 22.1, and among the girls 15.5. The calculated normal hemoglobin in the dessas Kebasekan and Kalimaro was, among the men 95, among the women 86, among the boys 85, and among the girls 85 —the same as at Gebongelir. The calculated loss due to hookworm disease in this dessa was, among the men 25.8, among the women 16.3, among the boys 13.5, and among the girls 2.0.

Estimated Loss of Hemoglobin due to Hookworm in a Population Subjected to Malaria. An estimate of the quantitative value of increasing numbers of hookworms in causing anemia was also made by analysing the large number of cases treated in the Malay States.

This series, excluding hospital patients, gave a total of 818 cases. Of these, 58 were boys and girls of mixed races, though mostly Eurasian, found in the Convent School at Kuala Lumpur; 75 were Malay boys found in the schools; and 92 were Tamil men, women, and children who worked on the public roads, and as night-soil coolies; 63 were Tamil men, women, and children who worked as coolies on rubber estates, and most of them had been exposed to malaria; 35 were Tamil men, women, and children detained in the quarantine camp at Port Swettenham; 58 were Chinese men, women, and children detained at the quarantine camp at Singapore; 55 were Chinese, Tamil, and Malay men at Prison No. 1; and 352 were

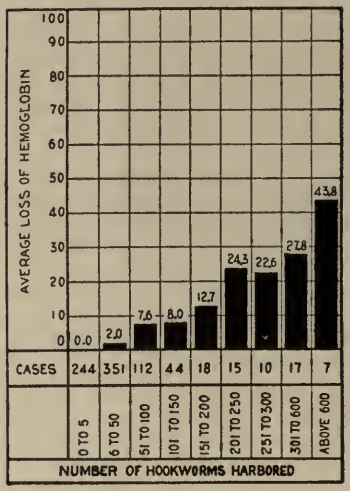

Fig. 87.—Estimated loss of hemoglobin due to hookworm disease, among populations subjected to malaria, by hookworm groups; 818 cases treated from schools, rubber estates, public works, quarantine camps, and prisons in Federated Malay States. (Table 50)

Chinese, Tamil, and Malay men at Prison No. 2. In these several groups treated and examined for hookworm disease, persons of both sexes and of different ages were included, and all varieties of physical condition in the working population were represented. The fact that the cases came from schools, rubber estates, public works, quarantine camps, and prisons, means that both urban and rural populations were represented.

Tables were made dividing the whole series into classes, according to the numbers of worms expelled by treatment; and the average hemoglobin of each class was calculated and comparisons made. (See Table 50, page 174.)

The hemoglobin average suffers no drop in the "1 to 5 worms" group as compared with the "0 worm" group. As these two groups contain a large number of cases, the average obtained by combining them will furnish a good standard for comparison with the other groups. Taking the average hemoglobin of the "0 to 5 worms" group, the difference between this and the average hemoglobin of each succeeding worm group will give the average amount of anemia caused by the corresponding number of hookworms. It will be seen that there is a steady loss of hemoglobin with an increasing number of worms. The rate of loss in the worm groups over 100 is higher than it is in the groups lower than 100. This is probably due to the host's ability to make good the losses due to a few worms.

The smaller number of worms presumably has the same proportionate effect in causing loss of blood as has the larger number, but the effect of the former is masked and not readily measurable. In these tables a loss of hemoglobin is understood to mean the measurable or evident effect of the infection, and does not include any loss which can be compensated for by blood regeneration. In the table based on analysis of all the cases, the average loss of hemoglobin is 4.3 per cent per case and the average number of worms is 53.1. Therefore the ratio of the loss of hemoglobin to the number of worms is 1:12.3.

Fig. 88.—Group of children living on an unhealthful rubber estate in the foothills of the Malay States. Of this type of estate it was said, "Not only is it impossible for pregnant women to escape miscarriage, but it is suspected that on account of the impotence of the men, due to the severity of the malaria, some of the women never become impregnated." Only one of these children was born on the estate. Spleen rate, 85%; parasite rate, 67%; hookworm incidence, 95%

Fig. 89.—Tamil children on an estate relatively free from malaria. Spleen rate, 7%; hookworm incidence, 100%; average hemoglobin of negative spleen cases, 72%; positive spleen cases, 30%. Compare with Fig. 88, showing group from severely malarious estate

The foregoing cases are taken irrespective of the evidence of malaria. When a separate analysis of the cases having evidences of malaria (plasmodia or enlarged spleen) is made, it is seen that the hemoglobins are set at a lower level, the average hemoglobin of the "0–5 worms" group being 74.5. Among prisoners in Java it was 76.5, instead of 83.7 as in the group without evidences of malaria. This depression of the average hemoglobin is encountered in each group and is due to the effect of malaria. The difference between 83.7 and 74.5 (or 9.2) is due to malaria and may be compared with the amount 10.5 found among prisoners in Java. In 155 cases with evidences of malaria the average loss of hemoglobin is 5.9 per case below the "0–5 worms" standard (74.5), and the average number of worms is 84. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 14.2.

In 663 cases without evidences of malaria the average loss of hemoglobin is 3.2 per case below the "0–5 worms" standard (83.7). The average number of worms is 45.8. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 14.3.

The average loss due to hookworm is greater in the malaria cases, but the average number of worms is greater also. The fact that the ratio of loss of hemoglobin to the numbers of worms is the same in the malarial and non-malarial groups shows that the worms present exert an equal influence and the difference in loss of hemoglobin is due to the greater number of worms harbored by the malaria cases. This indicates that a given number of worms has the same effect on cases with malaria as it does on cases without evidences of malaria. However, in the groups containing a larger number of worms the losses due to hookworm are greater in the cases showing evidences of malaria.

An analysis of the series into race, age, and sex groups may be made in the same way.

In 361 Chinese men, women, and children the average loss of hemoglobin is 1.4, irrespective of evidences of malaria. The average number of hookworms is 22.1. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 15.8.

In 172 Tamil men, women, and children the average loss of hemoglobin in the group is 5.3 per case, irrespective of evidences of malaria; the average number of worms is 106. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 20.

The Tamils show a larger loss due to hookworm than the Chinese, but the Chinese have a lower ratio between the loss of hemoglobin and the number of worms. This means that fewer worms are required to produce a given loss of hemoglobin in the Chinese than in the Tamils. It is shown elsewhere that Chinese harbor a greater number of *A. duodenale* than the Tamils do. This is a more malignant worm than *Necator americanus*, and causes more severe anemia. Undoubtedly the differences noted above are due to the large proportion of *A. duodenale* in the Chinese.

In 459 men the average loss of hemoglobin is 1.7, and the average

number of worms is 41. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 24.4.

In 44 women the average loss of hemoglobin is 9.9 per case, and the average number of hookworms is 98. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 10.

In 160 children the average loss of hemoglobin is 5.3, and the average number of worms is 44.5. Therefore the ratio of the loss of hemoglobin to the number of worms is 1: 8.4.

These ratios show that to produce a given loss of hemoglobin more worms are required in a man than in a woman, and more in a woman than in a child.

From this method of analysis the conclusions reached are: (1) that in a population the loss of hemoglobin due to hookworm disease may be measured, within certain limitations, by comparing the hemoglobins of cases having high worm counts with the hemoglobins of cases with low worm counts; (2) that the greatest possible benefit to be expected from treatment may be estimated, with the same limits of error, in any hundred cases of the population; (3) that the effect of a given number of worms in cases with evidence of malaria is, on the whole, the same as that in cases without evidence of malaria, but in this series of 818 persons, the cases with evidence of malaria (i. e. plasmodia and splenic enlargement) showed a greater number of worms and a correspondingly greater loss of hemoglobin than the cases without evidence of malaria at the time of examination; (4) that fewer worms are necessary to cause a given loss of hemoglobin in Chinese than in Tamils, and that this is probably due to the greater percentage of the more malignant Ancylostomes in the Chinese; (5) that fewer worms are required to produce the same loss of hemoglobin in children than in women, and fewer in women than in men.

Anemia in the Fiji Islands. In the course of its investigations in the Fiji Islands the Commission examined a group of Europeans consisting of 41 men, 10 of whom had been born in Fiji, the rest having resided in Fiji from 5 years and under, to 20 years and over. The average hemoglobin of these men was 88.8 per cent, which was the highest of any group examined on that particular island where the investigations were made (Viti Levu). As a rule they were living under excellent hygienic conditions. Upon examination of their stools it was found that only six were positive for hookworm disease, and even among these the number of worms harbored was apparently too small to influence their hemoglobin unfavorably, for their hemoglobins registered 85, 90, 91, 92, 94, and 100 per cent.

Examination was made of 18 of the European women, all with the same length of residence on the island. Their average hemoglobin was found to be 83.9 per cent, which was the highest average found among the women. They were all free from hookworm disease. The average hemoglobin of the 13 European children examined, between 4 and 15 years of age, was 82.3 per cent.

Three hundred twenty-three indentured Indian men were examined. As a class, they were found to stand highest among the colored population, their average hemoglobin being noticeably superior to that of the free Indian men, either town dwellers or agriculturists. Thirty of the former were examined and 139 of the latter. This superiority is doubtless due to the better hygienic conditions under which the indentured Indian lives, and to the medical inspection and hospital treatment which he receives. Sixty-four Fijian boys were examined at the Victoria School, their ages ranging from 9 to 17 years. The average hemoglobin for the group was but slightly under that for the European men, i. e. 88 per cent. As a class, these boys stood very high. They were, for the most part, sons of chiefs and came from vigorous stock. Their nourishment had always been carefully provided for and it would be expected that their hemoglobins would be higher than those of less fortunate natives. It is pertinent to mention in this connection that in the treatment squad of Fijians from Nausori village there were two chiefs and their hemoglobins were the highest in the squad.

There was very little difference between the hemoglobin contents of the free Indians and of the Fijians who lived in the villages near Nausori. The people in both groups were well-fed, comfortably housed, and not overworked. In all probability they were not exposed to hookworm infection to as great an extent as the free Indians living in the cane. The average hemoglobin of the Fijians stands a little higher than that of the Indians. Here, as elsewhere, the hemoglobin values of women were found to be influenced considerably by pregnancy. Wherever pregnancy was evident at examination, or was admitted by the women, the case was not considered in the tabulation of statistics. In fact very few women were included in the treatment squads, because there are reasons for believing that the statements of the women at the time of examination were unreliable. It has been thought best to base comparisons of worms and hemoglobins exclusively on the figures for men.

Relation of Hookworm Disease to Anemia in Fiji. It had been hoped it would be possible to ascertain with some exactitude the effect of hookworm infection in causing anemia in a population free from malaria, but in order to do this it would have been necessary to compare the hemoglobin of men free from hookworms with that of men harboring various numbers of worms. But hookworm infection was found to be so nearly universal in the class of men from which it was desired to elicit information that it was not possible to find a single non-infected man to furnish a basis for comparison.

The only portion of the adult male population free from hookworm infection was European, and with them diet and occupation would make direct comparison unreliable, for the reason that the more liberal diet, the lesser exposure to sun and rain, and the lighter labor of the European must give him a certain advantage. Attention should be called to the high hemoglobins observed in the well-fed but bedridden Chinese beriberics in the Batavia Stadsverband, and

to the higher hemoglobins of the prisoner clerks in the Batavia jail as contrasted with their fellow prisoners at hard labor.

If such conditions as hard labor, jail regimen, insufficiency of food, and the like, influence nutrition and hemoglobin values, and if these conditions vary in different communities under varying circumstances of life, it would seem almost impossible to make any observations which would be strictly comparable. Attempts to compare Chinese, Tamils, Fijians, and Europeans, therefore, will be subject to error resulting from differences in nutrition. The two species of hookworm, *Ancylostoma duodenale* and *Necator americanus*, it has been shown (see page 106, section, "Relation between Species of Worms and Degree of Anemia"), possess different degrees of malignancy. It will be impossible, therefore, to make exact comparisons based on total worm counts where the proportion of the two species varies very much. It would be necessary to study a much larger number of cases than the Commission was able to study, in order to minimize discrepancies due to individual variations in hemoglobin. It is possible only to give the results secured in the limited time at the disposal of the Commission and to point out their probable indications.

In attempting to ascertain the degree of anemia caused by different numbers of hookworms, adult Indian males have been taken as representative of the male standard of hemoglobin. Women and children follow a different standard, and (the former especially) show greater individual variations in hemoglobin. Fijians have been excluded from consideration because of the uncertainty as to what influence racial constitution, diet, and mode of life may exert on their hemoglobins. Besides, their numbers are small.

Attention has already been called to the low hemoglobins encountered among the Indians in the Suva jail. This was true of the entire group as well as of the individuals selected from the treatment squads. When it came to treating the men it was found that the number of worms obtained was insufficient to account fully for the degree of anemia observed. Later, examination and treatment of the indentured Indians at Nausori showed their hemoglobins to be uniformly higher, although they were harboring a slightly larger number of worms than the Indians in the jail. Apparently jail regimen tended to lower the condition of nutrition of the prisoners and made the noted differences in hemoglobin. The two groups of men harboring from one to fifty hookworms may be directly compared.

	Number of worms	*Number of cases*	*Average hemoglobin of group*
Jail prisoners	1 to 50	19	76.3
Indentured coolies	1 to 50	31	85.8

Here it is seen that although the indentured coolies harbored as many hookworms as the prisoners, the average hemoglobin of the

former was 9.5 points higher. This would seem to indicate that, irrespective of their hookworm infection, the indentured coolies who are regularly employed and paid, and who are free to diet themselves, do keep their bodies in a better state of nutrition and exhibit a higher standard of hemoglobin than the prisoners, and that the superiority of the former is due mainly to better diet.

It is evident that if it is desired to learn the measurable loss of hemoglobin due to various numbers of hookworms we must note such differences as are encountered among two such groups of men as we have just referred to—differences in the hemoglobin values which we must attribute to something other than difference in numbers of hookworms, for the number of worms (one to fifty) is the same in each group. Some contributory cause, or causes, of loss of hemoglobin must be present in the jail group.

Concerning the indentured coolies as a class, it is not possible to say what the average hemoglobin of a non-infected portion of the population might be, for there was no non-infected portion. The average hemoglobin of men harboring fewer than 10 worms was 88.8 per cent. If we consider the group of indentured men who harbored from 1 to 50 worms, we find the average hemoglobin of the 31 cases to be 85.8 per cent. Considering the next group, or those men with from 51 to 100 worms, we find that the average hemoglobin of the 16 cases is 85.0 per cent. It may therefore be assumed that if the addition of 50 worms depresses the hemoglobin only 0.8 per cent, the hemoglobin of men free from hookworms should not be far from 86.0 per cent. One hundred worms, or fewer, do not seem to cause any measurable loss in hemoglobin. In the next group, the coolies have from 101 to 150 worms; the average hemoglobin of the 9 men is 81.8 per cent. Here, apparently, the load seems to be too heavy to be borne without measurable loss in hemoglobin.

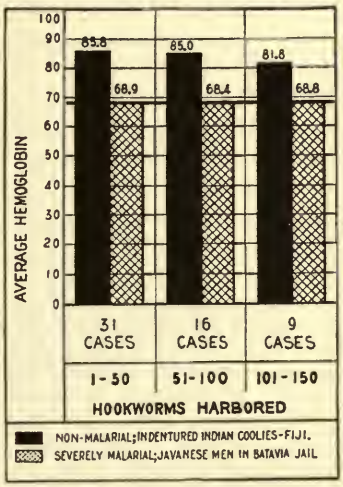

Fig. 90.—Diminished hemoglobin from prolonged malaria infection superimposed upon hookworm infection. Note: Heavy horizontal line indicates hemoglobin loss due partly to malaria and partly to jail regimen. (Table 51)

Attention has been called to the difference between the hemoglobin of the indentured coolies, and that of the prisoners in the jail who were living under a different regimen. The effect of prolonged mala-

ria infection superimposed upon men already infected with hookworm disease may be seen by comparing the indentured Indian coolies with a group of Javanese from three kampongs and from the Batavia Jail, who were heavily infected with malaria. The data are exhibited in Table 51, page 175.

Here the hemoglobins of a group of indentured Indians who were not heavily infected with hookworm disease, and who were not suffering noticeably from anemia, are compared with those of Javanese of similar classes who were suffering severely from malaria and who were at hard labor. The Indians were in good physical condition and were engaged in agricultural pursuits. Their hemoglobins were fairly high, but we have no doubt that if it had been possible to take them from the fields and put them on a regimen of very light exercise with a rich diet, their hemoglobins on the average could have been raised four or five points higher in spite of their hookworm infection.

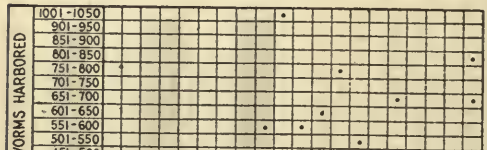

Fig. 91.—Correlation between number of hookworms harbored and rate of hemoglobin; 131 Indians free of malaria but infected with hookworm disease at Nausori and in Suva jail. Fiji Islands. Each dot indicates one person. (Table 52)

Considering the scarcity of labor, the approach of the cane-crushing season, and the time limitations, it would have been impossible to carry out such an experiment, and the strong probability of such factors as diet and hard labor influencing the hemoglobin content can be assumed only from the observations on the night-soil coolies of Kuala Lumpur, on bedridden Chinese beriberics in the Batavia Gefangenis, and on the prisoners at Batavia and Suva. In the Hospital ward at Kuala Lumpur, observations on the slow convalescence from severe malarial anemia of some of the vegetarian rice-eating Tamil patients, when compared with the more rapid recovery of the meat-eating Chinese, suffering from anemia of similar cause, undoubtedly have a bearing on this question.

With the possible exception of the Fijians, the group of men harboring from 1 to 150 worms, and having the highest average hemoglobins, is represented by the indentured coolies. The indications are that the Fijians would stand as high or higher, but the number of treated cases is too small to offer precise information on this point.

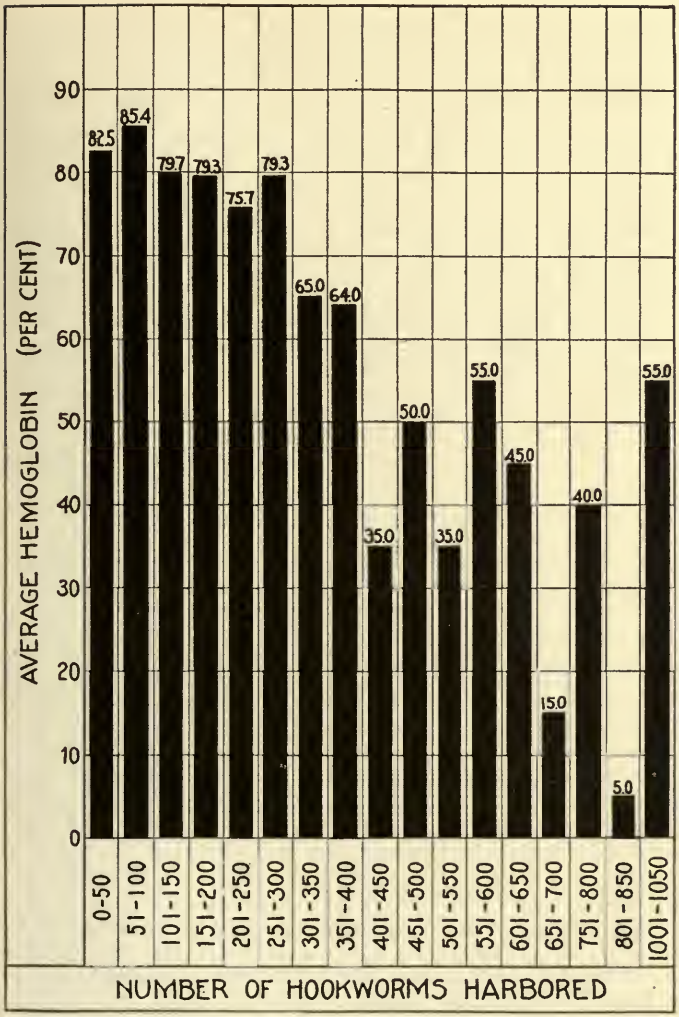

Fig. 92.—Correlation between number of hookworms harbored and rate of hemoglobin. Based on Fig. 91. (Table 52)

The Fijian treatment squad contained two well-nourished chiefs, and the hemoglobins of the treatment squad were higher than those of the population from which most of the men came. These facts are brought out in correlation Table 52, page 176.

The 131 cases included in this correlation table were all Indian men. They included Nausori Indians, both indentured and free, and a small number from Suva jail. All were infected with hookworm disease to a greater or less extent.

On account of the comparatively small numbers in the different worm and hemoglobin groups, and the inclusion of prisoners who were underfed, deductions must be made with caution. However, certain generalizations are possible. Judging by the disposition of the cases in the body of the table, no marked positive correlation of number of worms to measurable loss in hemoglobin will be seen until the 251–300 group is reached. If the cases with 250 worms or fewer are counted, it is seen that nearly 80 per cent of the whole group of 131 show little measurable loss of hemoglobin attributable to the worms found at treatment. Where the worm content is 251 or over, the loss of hemoglobin, as worms increase, is striking. As several cases of severe anemia were included, the proportion of low hemoglobins in the treated squads exceeds that found in the population as a whole, and the table gives the impression of a greater amount of hookworm anemia than was probably present in the community.

The hemoglobin averages printed at the left of the table show great oscillation, as might be expected of averages of relatively small numbers of highly variable units. There is no striking reduction in average hemoglobin until the 301–350 group is reached, since the average of the 251–300 group (79.3 per cent) is but little below that of the 0–50 group (82.5 per cent). When the worm content is 301 or over, a marked reduction in average hemoglobin is noticeable. The average hemoglobins of all worm classes below this point run from 10 to 50 per cent below the lowest of any superior class, i. e., any class with 300 worms or fewer. When the hemoglobin registered above 85 per cent, there was little tendency toward decrease, even though hookworm infection was present. On the whole, the hemoglobins of this malaria-free group apparently kept up in the presence of a comparatively high number of worms. Beyond a certain worm count the hemoglobins fell rapidly.

Relation Between Species of Worms and Degree of Anemia. It was observed by the Commission that in cases of infection the same number of worms caused a greater degree of anemia among Chinese than among Tamils. As Chinese harbor much larger numbers of *A. duodenale* than Indians do, the fact was taken to indicate that Ancylostomes are more malignant than Necators.

Two Chinese suffering from severe anemia were studied. Their faces were of a peculiar, waxy pallor, but there was no edema; malaria plasmodia were absent on admission, and their spleens were not palpable. Inasmuch, therefore, as malaria as a cause of anemia was

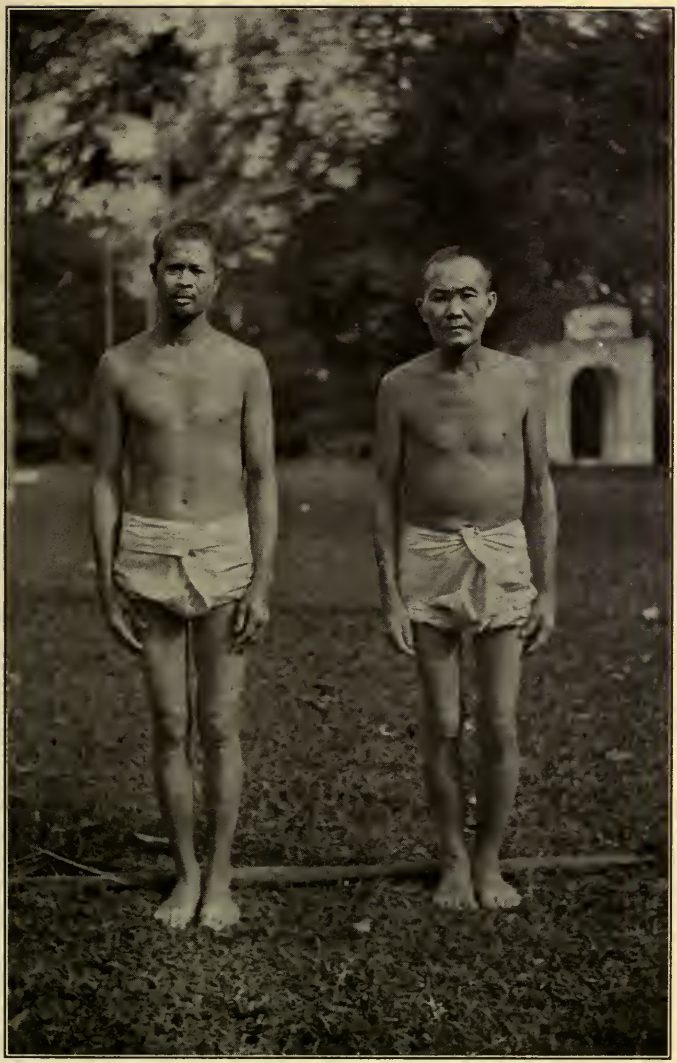

Fig. 93.—Tamil and Chinese with severe anemia and waxy pallor. No improvement after treatment. The blood-forming organs had become exhausted

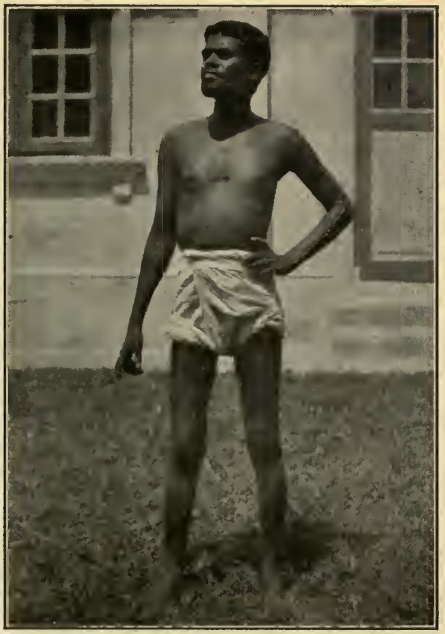

Fig. 94.—Hospital patient just before discharge and after hookworm treatment. This man went out to work on a malarious estate, contracted severe malaria, and returned broken down and edematous

Fig. 95.—Same case as Fig. 94, four and one-half months after discharge from hospital. Malarial cachexia. This condition is frequently mistaken for hookworm disease

absent, it was presumed from their appearance that they must have been harboring large numbers of hookworms. (See Fig. 93.) As a matter of fact, on treatment they yielded only 302 and 265 worms respectively. This fact naturally led to the inference that Ancylostomes, by giving rise to greater hemorrhage, might be the cause of a more severe grade of anemia than Necators.

This inference was more or less confirmed by a post-mortem examination of a Chinese who harbored 1,203 *A. duodenale* and 116 *N. americanus*, and in whom there was profuse hemorrhage directly due to worm bites. The hookworms that were recovered were bathed and imbedded in pale, bloody mucus. Numerous worm bites were seen, surrounded by circular areas of hemorrhage, but such worm bites were not nearly so numerous as the number of attached worms. It is therefore evident that hemorrhage does not occur from every worm bite. Practically all of the hookworms found were in the jejunum; none were in the ileum. It was not uncommon in treatment cases to find *A. duodenale* with bloody intestinal tracts; in fact, two of the three cases with lowest hemoglobins, treated in Penal Institution No. 3, showed bloody worms in the first washings after treatment. It was observed that among cases of infected Chinese on the one hand, with their large number of Ancylostomes, and among Tamils on the other hand, with their nearly purely Necator formula, equal numbers of worms did not cause anemia of equal severity. It was thought possible that the *A. duodenale*—with its larger and more strongly armed chitinous mouth-parts—might cause more hemorrhage and more anemia than the smaller, weaker-mouthed Necator.

A series of experiments was conducted and the results of the experiments were tabulated. Out of a total of 90 cases of Chinese, there were 16 that harbored 40 or more Ancylostomes—in addition to the Necators present. Five harbored from 46 to 129, and 6 from 85 to 265, while 5 harbored from 253 to 1,203. A clinical examination showed that several of the patients were suffering from severe anemia. There were four deaths.

Out of a group of 16 Tamils examined in this connection, there were only two cases of uncomplicated hookworm anemia. The first of these harbored no Ancylostomes and 710 Necators, and the second harbored 2 Ancylostomes and 1,061 Necators; both were anemic and had more or less edema, but neither was broken down. Of the 16 Tamils, 14, or 87.5 per cent, showed evidence of malaria, but in spite of this malaria and the number of hookworms harbored (mostly Necators) there were no deaths. In fact, in the group of 16 Chinese examined, only 8, or 50 per cent, gave evidence of malaria, although as a matter of fact the anemia present was very severe and 5 out of the 16, or 31.2 per cent, died. These facts are significant and indicate that *Ancylostoma duodenale* is probably a more powerful agent in the causation of anemia than *Necator americanus*.

Another type of patient was found (a Tamil who had been a vagrant for one and one-half years) who had both malaria and hook-

worm disease, and in whom edema, ascites, and diarrhea were evident. Although 550 hookworms were removed—32.3 per cent being *A. duodenale* probably derived from Chinese sources—his condition, far from improving, actually grew worse. For five weeks after admission there was no change in the condition of slight edema and ascites. After the sixth week, the edema of the legs increased rapidly and this condition lasted for five weeks, after which the edematous condition diminished for two weeks, only to return subsequently for another period of two weeks. During the third week diarrhea made its appearance and was severest two weeks before the time when the edema was mildest, and all through the period of severe edema the diarrhea was equally severe. The severity of this case was due in part to the large number of *A. duodenale*.

Severe Malaria (Cachexia) Mistaken for Hookworm Disease. In the hospital, study was made of a series of cases which included men free from hookworm but suffering from severe malarial anemia, with edema and debility. The importance of this particular series lies in the fact that while the wretched physical condition of the men was found to be entirely due to malaria, the patients were of the type whose symptoms are usually diagnosed by practitioners and intelligent laymen as cases of ancylostomiasis or uncinariasis. The malaria factor is almost always entirely overlooked. A typical case, with conclusive evidence that the condition found was due to malaria and not to hookworm, was that of Murugan, a Tamil dhoby. In July, 1915, this case was treated for malaria in the hospital ward. He was admitted on July 6, with malaria and hookworm disease.

On July 8, the examination of feces for hookworm ova revealed the fact that a few were harbored. Examination of blood on July 8, 10, 12, 14, 16, 19, 21, 23, 26, and 28 showed crescents. Examinations on August 2 and 3 showed the blood to be negative for plasmodia. The examination on August 4 again revealed crescents. Examination on August 6, 9, and 11 showed the blood to be negative for plasmodia, and the examination on August 12 showed subtertian rings. From July 8 to 19 the patient received quinine treatment. On August 4 chenopodium treatment was administered and 39 hookworms were recovered. On seven subsequent examinations (August 9, 10, 11, 12, 13, 14, and 17) his stool remained negative for ova. On August 9 he had a paroxysm of malaria and his temperature remained remittent for four days. On the fourth day plasmodia were again found. A slight edema of the feet, noticed upon admission, disappeared rapidly. Before the paroxysm of malaria occurred, his hemoglobin had risen from 28 to 67. Five days after this his temperature reached normal, when there was no edema—then he left the hospital abruptly.

Twenty-seven days later he returned, after spending the larger part of the interval at Kajang, twenty miles away. For three days he worked as a dhoby in Kuala Lumpur. His fever returned and he took quinine. Unable to work, he was cared for by his friends.

His face and legs began to swell and he returned to the hospital, presenting a wretched appearance. Investigation showed that he had severe anemia, that his face was puffy, and that there was slight edema of legs and feet as well as some emaciation. The condition which he presented is frequently miscalled ancylostomiasis; but as a matter of fact his stools were found to be negative for hookworm ova on seven examinations. On the other hand, his spleen was greatly enlarged, below the umbilicus, and plasmodia were found in his blood—subtertian and B. tertian rings.

It will be recalled that, when he left, his hemoglobin registered 67 per cent. Upon his return it was found that it had dropped to 12 per cent, while the erythrocytes had fallen from 66.3 per cent to 18.8 per cent. He responded to treatment and made a fairly rapid recovery, his hemoglobin rising to 68 per cent in 35 days, or an average of 1.6 per cent per day. The Commission found many similar cases. Investigation revealed a number of cases of Tamils or Malabaris who had severe anemia, edema, and debility, but who harbored only small numbers of hookworms. On account of the similarity of these cases to the foregoing, the cause of the symptoms was attributed to malaria rather than to hookworm.

Rate of Blood Regeneration in Hookworm Disease and in Malaria. As has already been pointed out, a special ward at the hospital at Kuala Lumpur was assigned to the Commission for its use. One of the problems which the Commission undertook to solve was whether or not hookworm infection retarded blood regeneration in malaria, and, if so, to what extent.

Chinese and Tamil coolies who were in a badly broken-down condition were admitted to the hospital. In some of these cases severe and extreme anemia was detected. When the examinations of feces and blood were being made of the 332 patients who were admitted into the ward, hemoglobin determinations were carried out on them at the same time. An analysis of the results disclosed a very striking difference between the hemoglobin contents of the Chinese and of the Tamils, when the findings (with reference to the presence or absence of malaria and hookworm disease) were compared.

These examined cases fell into four groups: (1) those who had neither hookworm disease nor malaria; (2) those who had hookworm disease only; (3) those who had malaria only; and (4) those who had both malaria and hookworm disease.

The classification "malaria only" merely implies the presence of plasmodia in the peripheral blood at the time, as detected in the thick film. Absence of hookworm disease may be taken to mean absolute absence, as well as, in some cases, such sparseness of ova in the specimen that they were not detected. Inasmuch as this usually means that few worms are present, it indicates that the anemia found was not due to the presence of any large number of worms. Absence of malaria does not necessarily indicate what may have taken place in the peripheral blood or in the viscera before

entrance to the hospital. As a matter of fact, the average hemoglobin of these cases showed that there had been a very severe loss of hemoglobin due to causes other than hookworm infection, but principally to malaria.

Classification "neither hookworm disease nor malaria" means that there might have been very few hookworms present, and that the degree of anemia indicated was the result of a recent attack of malaria, although plasmodia had disappeared from the blood stream at the time of examination. In each class the Chinese showed a decided superiority to the Tamils, so far as the average hemoglobin was concerned.

It will be seen by reference to the summary below that when the plasmodia or ova are demonstrable, the amount of anemia due to malaria is greater than the amount due to hookworm disease, there being about twice as much among the Chinese and about three times as much among the Tamils. Furthermore, it will be observed that the amount of anemia among the Tamils, due to hookworm disease, was found to be about twice as great as among the Chinese, while the amount of malaria was found to be about two and one-half times as great.

	Percentage Hemoglobin	
	Chinese	*Tamils*
Neither infection	48.8%	42.2%
With hookworm disease only	46.9%	38.7%
Loss due to hookworm disease	1.9%	3.5%
Neither infection	48.8%	42.2%
With malaria only	44.9%	31.7%
Loss due to malaria	3.9%	10.5%

It must be remembered, in noting these differences between the Chinese and Tamils, that to a certain extent they follow different occupations. The Tamils, for the most part, are employed on rubber estates and on public works, while the Chinese for the most part work in tin mines, or as vegetable gardeners, artisans, and shopkeepers. Thus, the races are exposed in varying degrees to malaria. The religious and caste restrictions of Tamils prevent them from eating beef or pork, requiring them to be to a considerable extent vegetarians. On the other hand, the Chinese have no such dietary restrictions and eat heartily. These differences between the races undoubtedly affect their liability to infection, and also their ability to recuperate afterward. Behind such influences as occupation and environment as related to the amount of illness of the respective races, there appears to be something deeper and more of the character of ethnic vitality, temperament, or metabolism.

During physical examination the reflex activities of the Chinese are at once noticeable, as is shown in the difficulty experienced by

the examiner in taking their spleen rates. While the Tamils have a soft, flaccid belly-wall, usually free from rigidity, the abdominal wall of the Chinese almost jumps to meet the hands of the examiner. This rigidity is more or less a rule among the Chinese men, and interferes not a little with the rapidity or accuracy with which their spleen rates can be taken. This reflex nervous irritability is an index of something far more commonly seen in Chinese than in other races. There are other indications, also, that the Chinese as a race are more vigorous and resistant to disease than are the Tamils: for example, the comparative rapidity with which they convalesce from debilitating disease and the extraordinary way their tissues react to the virus of syphilis.

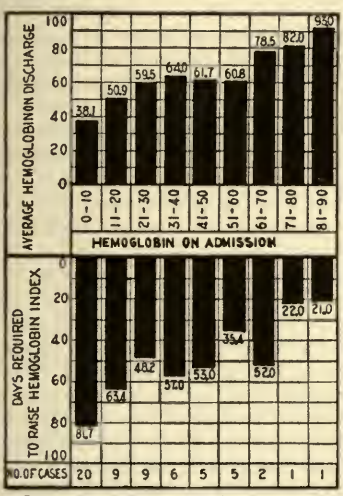

Fig. 96.—Time required to raise hemoglobin rates of anemic patients, following treatments for malaria and hookworm disease. Fifty-eight cases treated in special ward at Kuala Lumpur hospital. (Table 53)

Table 53, page 177, with reference to the time required to raise the hemoglobin in anemic patients, shows that a very disappointing feature of the hospital work was the inability to raise the hemoglobin value up to normal after the patients had recovered from an attack of malaria, and after they had been treated and freed from their hookworms. Very often their general appearance would be good and their weight would have so increased that they would ask for their discharge, when as a matter of fact their hemoglobin registered only from 30 to 60 per cent. It was observed that the lower a man's hemoglobin was on admission, the greater was the difficulty in getting it up to 60 or 70 per cent. It was also observed that when it registered 10 per cent or less it was usually impossible to raise it to 70 per cent within three months.

The Commission was particularly anxious to ascertain whether hookworm infection retarded blood regeneration in malaria, and, if so, to what extent. In order to discover these facts it was necessary, (1) to determine the rate of blood regeneration in cases of pure hookworm infection; (2) to determine the rate of blood regeneration in cases of uncomplicated malaria, if such cases could be found; (3) to ascertain, if possible, what effect one infection had on the other —whether each advanced as though the other were absent, or whether there was any accentuation of either infection; and (4) to note

whether hookworm infection retarded convalescence from malaria, and whether relapse of malaria might not mask the benefit of hookworm treatment. It is true that the hospital yielded abundant material for investigation along these lines, but it is also true that a disadvantage was experienced because of the fact that the patients frequently absconded from the ward during treatment (29.5 per cent of the 332), thus making it necessary to abandon many experiments altogether, or else begin them all over again. A number of important experiments were ruined because of relapse due to malaria.* However, even this circumstance gave the Commission an opportunity to find the loss in hemoglobin during relapse, and at the same time to discover the effect of insufficient quinine medication in malaria.

The cases infected with both malaria and hookworm disease, in whom the hemoglobin had been reduced below normal, were treated thoroughly and at once with quinine for the purpose of arresting the development of malaria plasmodia, and in order to put a stop to the losses of hemoglobin. After this, it was possible to note the rate of blood regeneration in the patients, some of whom were harboring few hookworms and some of whom had many. By noting the increase in the hemoglobin and the increase of erythrocytes at stated periods during convalescence, it was possible, by administering chenopodium treatment and by counting the number of worms harbored, to ascertain the rate of hematopoiesis in those cases that were convalescing from malaria who harbored few hookworms, and among those cases that were convalescing from malaria who harbored many hookworms.

In order to determine the effect of harboring a large number of worms (presumably for a period of time so long as to exhaust the blood-forming organs to a degree where hematopoiesis would be slower than in a control that harbored few or no worms), two patients—as nearly in the same clinical class, so far as age, race, hemoglobin content, malaria, etc., were concerned as it was possible to obtain —were selected and treated, and their hookworms were recovered and counted. After several days or weeks, the rate of blood regeneration after treatment was determined and the results were compared. The results of these several experiments to ascertain the rate of blood regeneration in malaria and hookworm infection may be stated as given below:

a. Blood Regeneration in Uncomplicated Hookworm Infection. In instances of uncomplicated hookworm infection among the Chinese, severe cases improved very slowly, the rate of increase of hemoglobin being about 0.44 per cent per diem. It appeared to be impossible for the hemoglobin to return to normal limits. This may have been due to the bad physical condition of the patients treated, for the Chinese usually do not go to the hospital until they are quite unable to continue at work.

The rate of increase of hemoglobin in the Tamil who was a boy was much better, being 1.0 per cent per diem; but this is slower

* Result of insufficient quinine medication. A dishonest employe stole some of the quinine and falsely labeled the substituted solution that was used.

than the rate of regeneration after malaria. There is a long period, after complete removal of the worms, in which but very little change in the hemoglobin or erythrocytes is noted. This period considerably diminishes the per diem rate of increase.

b. Blood Regeneration in Uncomplicated Malaria Infection. It was difficult to discover cases of uncomplicated malaria. In the series treated, one of the patients continued to show for several days evidences of malaria by the presence of plasmodia. This symptom was probably due to insufficient dosage of quinine. His rate of blood regeneration, as measured by the increase in hemoglobin, was 1.2 per cent per diem during a period of 32 days. During that period while he had no plasmodia in his blood, the rate of increase in hemoglobin was 1.4 per cent per diem.

Two cases that had been previously treated for hookworm disease, and presumably were free from worms, had relapses. The rate of increase in hemoglobin in these two cases was 1.6 per cent and 1.4 per cent; the increase in erythrocytes was 1.4 per cent and 1.0 per cent respectively per diem.

In the cases of malaria and hookworm disease in which the number of worms present did not exceed 232 in the South Indians or 154 in the Chinese, the hemoglobin content and the number of erythrocytes do not indicate that the number of worms present interfered measurably with the rate of increase. A patient was able to regenerate blood after malaria as rapidly with a load of 205 worms as if he had had no worms at all.

When the malaria was associated with a much larger number of worms it was difficult for a patient to recover promptly. There were only two cases in this series and they were both in very bad physical condition on admission; they were treated early. In one of these cases it has been shown that the burden of carrying 600 worms apparently overtaxed the blood-forming organs to an appreciable extent, for the rate of regeneration after removal of the worms was distinctly slower than in a control who had been as ill from malaria, but who had harbored only a few worms. But it must be noted that this particular control, who showed the better rate of improvement at that time, returned four and one-half months later very badly broken down. On this occasion the rate of improvement was not so good—in fact it was almost as bad as that of the control carrying the 600 hookworms. These data serve to emphasize the truth that the blood-forming organs may regenerate well enough under a strain, provided they are not exhausted; and it shows that exhaustion may occur with malaria, with hookworm disease, or with both.

Greater Severity of Anemia in Women. Striking and apparently disproportionate amounts of anemia were discovered among the women on certain estates where there was severe malaria and among the night-soil coolies who were infected with hookworm disease and malaria. It was observed that, while the women (as a

whole) among the natives in some malarious kampongs in Java had hemoglobins usually up to what may be regarded as a dessa standard, pregnant women—particularly those in the last half of the period of pregnancy—showed a lower value. In the case of kampongs where the average hemoglobin of the pregnant women was found to be only 64.1 per cent, this fact is probably not to be regarded as altogether due to anemia, but to hydremic plethora, for women have a mechanism for the production of hydremic plethora; this mechanism is normally doubtless controlled by their endrocrinal glands. Some of the extreme cases of anemia in women may have been due to a perverted functioning of the glands as a result of severe malaria infection. The greater instability of the hemoglobin values of women may be observed by comparison of a group in those kampongs that were free from malaria, although heavily infected with hookworm disease, with a similar group who had severe malaria and but few hookworms. (See Table 54, page 178.)

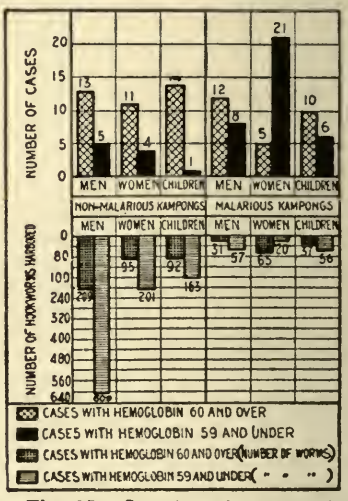

Fig. 97.—Severity of anemia in men, women, and children. Comparative hemoglobin rates of sexes in malarious and non-malarious districts. (Table 54)

It will be observed by reference to this table that the incidence of hemoglobins 59 per cent and lower was 2½ times greater among women than among men, among the treated cases in the malarious dessas, and therefore if the hemoglobin content of the women actually represented anemia, then the amount of anemia caused by malaria is 2½ times greater in women than in men. It was found that twenty-one twenty-sixths, or 81 per cent, of the women in the malarious dessas had hemoglobins of 59 per cent and lower, while only four-fifteenths, or 26.6 per cent, of the women who lived in the dessas which were non-malarious but which were heavily infected with hookworm, were in the same hemoglobin class. It is therefore safe to say that malaria causes three times as much anemia among the women in these kampongs as hookworm disease does in the other two kampongs. The fact that low hemoglobin values were found in pregnant women—and in women suffering from severe anemia due chiefly to malaria—should be kept in mind in estimating the average hemoglobins in various populations.

Anemia Among Chinese Coolies in Tin Mines. The Commission examined 200 workers in a tin mine, all of them Chinese. One hundred specimens of feces were collected. With respect to the hemoglobin content of these men, it was established by comparison with 303 Chinese prisoners at Penal Institution No. 2 that anemia was not present to any marked extent in the mine. The lower percentages of hemoglobin found in the jail were not met with among the workers in the mine. In fact, the lowest hemoglobin in the mine series was 45 per cent, while the lowest in the jail series was 35 per cent. This difference was probably due to the fact that there was a weeding-out process at the mine, whereas all sorts and conditions of prisoners were admitted and retained in the jail. It was found that the higher hemoglobins among the mine series were slightly inferior to those found in the jail, the highest in the mine being between 85 and 89 per cent, while the highest in the jail was between 90 and 94 per cent. This difference could be explained as probably due to the better conditions, the better food, etc., in the jail, and also to the fact that the average age in the mine series was somewhat higher than in the jail series. It was found that the hemoglobin content of the underground workers was slightly less than that of the surface workers, the average among 59 underground workers being 83 per cent, and the average among 141 surface workers being 84.2 per cent.

One hundred stools were collected and examined. Of the 32 underground workers, 84 per cent were found positive for hookworm disease, and 79.4 per cent of the 68 surface workers. Of 100 of the stools examined, 81 per cent were found to contain hookworm ova, which is almost exactly the same percentage as that obtained by examination of the feces of prisoners in the jails, i. e., 80.3 per cent.

No correlation was observed between the degree of hookworm infection and the amount of anemia, for although the underground workers were shown to have the lower hemoglobins (a fact quite in accord with their greater infection with hookworm) the cases found infected with hookworm showed no anemia when compared with the cases not infected. That is, the average hemoglobin of 81 cases infected with hookworm was found to be 85.1 per cent, while the average hemoglobin of 19 cases found to be not infected with hookworm was 80.8 per cent.

As for malaria, it was found to be unimportant. Enlarged spleens were found in 25 of the 200 cases, i. e. 12.5 per cent. The cases with enlarged spleens and average hemoglobin were 78.6 per cent. The other 175 cases had an average hemoglobin of 84.5 per cent. Blood examinations were made of 162 cases, and 3 of these, or 1.9 per cent, were found positive for malaria plasmodia, their average hemoglobin being 68.3 per cent.

TABULAR SUMMARY

TABLE 1

POPULATION OF FEDERATED MALAY STATES

By Race

Census of 1911

State	All Races	Chinese		Malays		Indians		Europeans		Eurasians		Others	
		No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.
Total	**1,036,999**	**433,244**	**41.8**	**420,840**	**40.6**	**172,465**	**16.6**	**3,284**	**.3**	**2,649**	**.3**	**4,517**	**.4**
Perak	494,057	217,206	44.0	199,034	40.3	73,539	14.9	1,396	.3	845	.2	2,037	.4
Selangor	294,035	150,908	51.3	64,952	22.1	74,067	25.2	1,348	.5	1,255	.4	1,505	.5
N. Sembilan	130,199	40,843	31.4	69,745	53.6	18,248	14.0	403	.3	464	.4	479	.4
Pahang	118,708	24,287	20.5	87,109	73.4	6,611	5.6	137	.1	85	.1	496	.4

(Fig. 2, page 1)

TABLE 2

PERCENTAGE INCREASE OF 1911 CENSUS OVER CENSUS OF 1901

State		All Races		Chinese		Malays		Indians		Europeans		Eurasians		Others	
		No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.
Total ...	**1901**	**678,595**	**52.8**	**301,463**	**43.7**	**313,205**	**34.4**	**58,386**	**195.4**	**1,459**	**125.1**	**1,526**	**73.6**	**2,556**	**76.7**
	1911	**1,036,999**		**433,244**		**420,840**		**172,465**		**3,284**		**2,649**		**4,517**	
Perak ...	1901	329,665	49.9	150,239	44.6	142,168	40.0	34,760	111.6	672	107.7	591	43.0	1,235	64.9
	1911	494,057		217,206		199,034		73,539		1,396		845		2,037	
Selangor .	1901	168,789	74.2	109,598	37.7	40,640	59.8	16,847	339.6	511	163.8	580	116.4	613	145.5
	1911	294,035		150,908		64,952		74,067		1,348		1,255		1,505	
Negri....	1901	96,028	35.6	32,931	24.0	56,935	22.5	5,526	230.2	142	183.8	309	50.2	185	168.1
Sembilan.	1911	130,199		40,843		69,745		18,248		403		464		496	
Pahang ..	1901	84,113	41.1	8,695	179.3	73,462	18.6	1,253	427.6	134	2.2	46	84.8	523	−8.4
	1911	118,708		24,287		87,109		6,611		137		85		479	

(Fig. 3, page 2)

TABLE 3

POPULATION OF FEDERATED MALAY STATES

SHOWING DENSITY

CENSUS OF 1911

State	Population 1911	Area (Sq. Miles)	Persons per Sq. Mile	Acres per Person
Total	**1,036,999**	**27,506**	**37.7**	**16.9**
Perak	494,057	7,800	63.3	10.1
Selangor	294,035	3,156	93.2	6.9
Negri Sembilan	130,199	2,550	51.1	12.5
Pahang	118,708	14,000	8.5	75.5

(Fig. 4, page 3)

TABLE 4

POPULATION OF FEDERATED MALAY STATES LIVING ON ESTATES

By Race

State	All Races	Indians		Chinese		Malays	
		No.	P.C.	No.	P.C.	No.	P.C.
Total	**158,134**	**94,950**	**60.0**	**40,026**	**25.3**	**23,158**	**14.6**
Perak	62,257	33,122	53.2	16,403	26.3	12,732	20.5
Selangor	67,375	49,910	74.1	10,666	15.8	6,799	10.1
Negri Sembilan	26,466	11,257	42.5	12,027	45.4	3,182	12.0
Pahang	2,036	661	32.5	930	45.7	445	21.9

(Fig. 5, page 4)

TABLE 5

POPULATION OF FEDERATED MALAY STATES ENGAGED IN PRINCIPAL OCCUPATIONS

MALE AND FEMALE

Occupation	Both Sexes	Males	Females
Total	**670,742**	**548,829**	**121,913**
Agriculture	323,065	231,356	91,709
Mining	163,680	156,327	7,353
Personal service	25,917	20,932	4,985
Government service	23,499	22,615	884
Commercial transportation	53,371	52,291	1,080
Miscellaneous	81,210	65,308	15,902

(Fig. 6, page 5)

TABLE 6

RESPECTIVE MERITS OF MICROSCOPIC EXAMINATION AND MEDICATION, AS MEANS OF REVEALING HOOKWORM INFECTION

By Race

Race	Persons Found Infected with Hookworm by Examination of Feces for Ova		Persons Found Infected with Hookworm by Treatment and Recovery of Worms Expelled	
	No.	P.C.		
All Races	**3,776**	**87.8**	**872**	**92.4**
Tamils	2,472	95.3	261	99.6
Chinese	783	73.4	453	90.1
Malays	206	88.8	97	99.0
Bengalese	25	84.0	2	100.0
Europeans	23	21.7	....	....
Singalese	3	100.0	....	....
Javanese	....	....	1	100.0
Eurasians and mixed races	264	65.9	58	67.2

(Fig. 18, page 22)

TABLE 7

RELATIVE ACCURACY OF HOOKWORM DIAGNOSIS BY FECES EXAMINATION, AS INDICATED BY LATER RECOVERY OF WORMS

TWO HUNDRED NINE CASES TREATED IRRESPECTIVE OF RESULT OF FECAL EXAMINATION

	Number	Per Cent of Total
Cases considered	**209**	**100.0**
Feces positive and treatment positive	176	84.2
Feces positive and treatment negative	5	2.4
Feces negative and treatment positive	17	8.1
Feces negative and treatment negative	11	5.3

(Fig. 22, page 26)

TABLE 8

WORMS RECOVERED FROM SEVENTEEN HOOKWORM CASES NEGATIVE BY FECES EXAMINATION, BUT POSITIVE BY TREATMENT

Case No.	Total Worms	Necators		Ancylostomes
		Male	Female	Male
1	1	1	0	0
2	1*	0	0	0
3	1	1	0	0
4	2	1	1	0
5	1	0	1	0
6	4	3	1	0
7	1	0	1	0
8	2	0	2	0
9	2	0	2	0
10	2	0	2	0
11	2	0	2	0
12	3	1	2	0
13	5	2	3	0
14	8	4	4	0
15	16	10	6	0
16	15	6	9	0
17	22	8	3	1

* Male *A. ceylanicum.*

TABLE 9

COMPARATIVE EFFECT OF THYMOL AND CHENOPODIUM ON TWO SPECIES OF WORMS

Thymol									Oil of Chenopodium								
Dose	Cases	Worms Removed by Entire Treatment			Worms Removed by Trial Treatment				Dose	Cases	Worms Removed by Entire Treatment			Worms Removed by Trial Treatment			
		Total	Necators	Ancylostomes	Necators		Ancylostomes				Total	Necators	Ancylostomes	Necators		Ancylostomes	
					No.	P.C.	No.	P.C.						No.	P.C.	No.	P.C.
40 grs	65	3,369	3,173	196	2,411	76.0	59	30.1	0.75 mils	10	220	179	41	158	88.3	26	63.4
60 grs	10	202	164	38	157	95.7	22	57.9	1.50 mils	49	2,747	2,491	256	2,422	97.2	205	80.1
90 grs	19	639	577	62	567	98.3	58	93.5	3.00 mils	20	460	381	79	379	99.5	76	96.2
120 grs	28	3,324	3,127	197	2,098	67.1	101	51.3	....	..	....	....	....	....	....	....	....

(Fig. 27, page 32)

TABLE 10

EFFECT OF FULL AND REDUCED DOSAGES OF THYMOL AND OIL OF CHENOPODIUM IN EXPELLING TWO SPECIES OF WORMS. TRIAL TREATMENT ONLY

NINETY-FOUR CASES TREATED WITH THYMOL; 79 WITH CHENOPODIUM

Dosage	Percentage Removed of Necators Present		Percentage Removed of Ancylostomes Present	
	By Thymol	By Chenopodium	By Thymol	By Chenopodium
Maximum	98.3	99.5	93.5	96.2
Two-thirds maximum	95.7	....	57.9	....
One-half maximum	....	97.2	....	80.1
Four-ninths maximum	76.0	....	30.1	....
One-quarter maximum	....	88.3	....	63.4

(Fig. 28, page 33)

TABLE 11

SUPERIOR EFFICACY OF CHENOPODIUM, AS COMPARED TO THYMOL, IN REMOVING MORE RESISTANT WORM SPECIES

Dosage	Superiority in Efficacy of Oil of Chenopodium	
	In Percentage of Necators Removed	In Percentage of Ancylostomes Removed
3.00 mils chenopodium = 90 gr. thymol	1.2	2.7
1.50 mils " = 60 gr. "	1.5	22.2
0.75 mils " = 40 gr. "	12.3	33.3

(Fig. 29, page 33)

TABLE 12

EFFICACY OF VARIOUS VERMICIDES IN EXPELLING HOOKWORMS AND EFFECTING CURE. THIRTY-EIGHT CASES

Drug and Dose	Cases	Worms Removed by			Cases Cured by Trial Treatment	
		Entire Treatment	Trial Treatment			
			No.	P.C.	No.	P.C.*
Beta-naphthol, 20 grains, in capsules, two doses with two-hour interval	10	165	44	26.7	0	0.0
Eucalyptus, 30 minims; chloroform, 45 minims; and castor oil to 12 drams, divided into two doses of 6 drams each and given at two-hour intervals	10	420	197	46.9	1	10.0
Thymol, 30 grains, in emulsion, two doses with two-hour interval	10	202	179	88.6	6	60.0
Oil of chenopodium, 1 mil in capsules, two doses with two-hour interval	8	104	100	96.2	5	62.5

* This column is included merely as an item of interest. The number of cases upon which the percentages are based is too small to make the percentage figures significant.

(Fig. 30, page 34)

TABLE 13

HOOKWORMS EXPELLED BY TWO TREATMENTS OF SMALLER-THAN-MAXIMUM DOSES OF THYMOL AND CHENOPODIUM. SIXTY-TWO CASES

Drug and Dose	Necators			Ancylostomes		
	Worms Removed by Entire Treatment	Worms Removed by Two Trial Treatments		Worms Removed by Entire Treatment	Worms Removed by Two Trial Treatments	
		No.	P.C.		No.	P.C.
Thymol, two treatments, 40 grains each, 23 cases	3,173	2,680	84.5	196	96	49.0
Oil of chenopodium, two treatments, 1.5 mils each, 39 cases	2,099	2,091	99.6	167	153	91.6

(Fig. 31, page 35)

TABLE 14

WORMS EXPELLED AND CASES CURED BY TWO HALF-MAXIMUM-DOSE TREATMENTS OF CHENOPODIUM, AS COMPARED WITH TWO 20-GRAIN TREATMENTS OF THYMOL IN VARIOUS FORMS

Drug and Dose	Cases	Worms Removed			Cases Cured by Trial Treatments	
		Entire Treatment	Trial Treatments			
			No.	P.C.	No.	P.C.*
1. Two treatments of oil of chenopodium, 0.5 mils in capsules, three times at hourly intervals	39	2,266	2,244	99.0	27	69.2
2. Two treatments of thymol in capsules, 20 grains twice with two hours' interval	23	2,032	1,695	83.4	6	26.1
3. Two treatments of thymol, 20 grains in capsules, with lactose, 20 grains; two doses with two hours' interval	10	887	704	79.4	3	30.0
4. Two treatments of thymol, 20 grains ground to fine powder twice with two hours' interval	10	67	54	80.6	3	30.0
5. Two treatments of thymol, 20 grains, and lactose, 20 grains, ground to fine powder; two doses with two hours' interval	18	383	323	84.3	6	33.3

* See Table 12.

(Fig. 32, page 35)

TABLE 15

WORMS EXPELLED AND CASES CURED BY CHENOPODIUM IN VARIOUS DOSES

SINGLE TRIAL TREATMENT

Dose	Cases	Worms Removed			Cases Cured by Trial Treatment	
		Entire Treatment	Trial Treatment			
			No.	P.C.	No.	P.C.*
1. Oil of chenopodium, 1 mil in capsule; three doses at hourly intervals, or 3 mils	17	460	455	98.9	14	82.4
2. Oil of chenopodium, 1 mil in capsule; two doses with two hours' interval, or 2 mils	8	104	100	96.2	5	62.5
3. Oil of chenopodium, 2 mils in capsules; one dose only, 2 mils	30	545	522	95.8	21	70.0
4. Oil of chenopodium, 0.5 mils in capsule; three doses at hourly intervals, or 1.5 mils	9	481	459	95.4	5	55.6
5. Oil of chenopodium, 0.5 mils in liquid paraffin, ½ oz.; three doses at hourly intervals, or 1.5 mils	10	275	244	88.7	4	40.0
6. Oil of chenopodium, 0.25 mils in capsule; three doses at hourly intervals, or 0.75 mils	10	230	184	80.0	4	40.0
7. Oil of chenopodium, 10 minims, or just over 0.5 mils, in X's gelatine capsules; three doses at hourly intervals, or 30 minims	10	107	71	66.4	6	60.0
8. Oil of chenopodium, extracted from X's gelatine capsules, 0.5 mils, in freshly filled capsule, three doses at hourly intervals, or 1.5 mils	4	95	93	97.9	2	50.0

* See Table 12.

(Fig. 33, page 36)

TABLE 16

WORMS EXPELLED AND CASES CURED BY THYMOL IN LARGE DOSES

SINGLE TRIAL TREATMENT

Dose	Cases	Worms Removed			Cases Cured by Trial Treatment	
		Entire Treatment	Trial Treatment			
			No.	P.C.	No.	P.C.*
Thymol, 30 grains, in powder, three times, or 90 grains	19	639	625	97.8	14	73.7
Thymol, 40 grains, in powder, three times, or 120 grains	19	2,384	1,292	54.2	8	42.1
Thymol, 1 dram, in powder, three times, or 180 grains	9	940	907	96.5	6	66.7

* See Table 12.

(Fig. 34, page 37)

TABLE 17

SUMMARY OF RELATIVE VALUES OF THYMOL AND OIL OF CHENOPODIUM IN TREATING HOOKWORM DISEASE

Thymol	Oil of Chenopodium
1. The 90-grain dose produced a very satisfactory removal of worms.	1. Three mils produced the largest vermifugal effect of any single treatment tried, but the result was only slightly superior to the corresponding dose of thymol.
2. Higher doses, for example 120 grains, removed fewer worms because the vomiting that occurred reduced the amount of drug retained in the stomach to below the amount required for efficient removal of worms; but with 180 grains, though much vomiting occurred, the amount of the drug retained was still sufficient to effect a satisfactory removal of worms.	2. The dose at which the vomiting caused loss of efficiency was not reached at one institution, although 3 mils were given. At another, 46.9 per cent of vomiting occurred with loss of efficiency at the dosage of 15 minims three times, or 2.8 mils.
3. No serious toxic symptoms were noted even with the highest dose.	3. The highest dose (i. e., 3 mils) occasionally produced toxic effects on the nervous system, such as nerve deafness and coma.
4. No serious toxic symptoms were noted even with the highest dose.	4. In the lower doses, 1.5 mils and under, no deafness or coma occurred.
5. Diminution of the dosage produced a rapid falling off of efficiency.	5. The efficiency was well maintained when the dose was reduced even down to a quarter of the maximum dose.
6. Two treatments with a small dose did not produce a good summation of results.	6. Two half-maximum doses produced a better result than the full maximum dose, and the highest percentage of worms removed was obtained by this treatment, i. e., 99.6 per cent of Necators and 97.5 per cent of Ancylostomes.

(Concluded next page)

TABLE 17 (concluded)

Thymol	Oil of Chenopodium
7. Thymol was voted, by a great majority of the patients treated, as more unpleasant to take than oil of chenopodium.	7.
8. The characteristics noted under 5, 6, and 7 render thymol less suitable for use in the treatment of children than oil of chenopodium, as for children the smaller dose would be required.	8.
9. The effect on the more resistant forms of worms has been shown to be less, dose for dose, with thymol than with oil of chenopodium.	9. This renders chenopodium as the drug for choice in treating Chinese, West Indians, or any other people with a high percentage of ancylostomes.
10. Thymol, being a relatively insoluble powder, has less opportunity than chenopodium of becoming uniformly distributed throughout the intestinal contents.	10. Chenopodium, being a thin oil, will become more evenly diffused along the intestine.
11. According to consideration No. 10, the action of thymol was less uniform than that of chenopodium, and there were 23.6 per cent of cases in which relative failure of the treatment occurred.	11. Only 7.6 per cent of the patients treated with chenopodium showed relative failure of treatment.
12. Thymol removes a certain proportion of the worms of species other than hookworms.	12. Oil of chenopodium has been shown to be more effective than thymol in removing all the other species.

TABLE 18

COST OF THYMOL AND CHENOPODIUM, WITH COMPARATIVE EFFICACY BASED ON WORMS EXPELLED

Drug and Dose		Cost		Percentage Removed of Total Worms Present	
Thymol in grains	Chenopodium in mils	Thymol	Oil of Chenopodium	Thymol	Oil of Chenopodium
40	0.75	$0.06	$0.014	73.3	80.0
60	1.5	0.09	0.028	88.6	95.7
90	3.0	0.135	0.055	97.8	98.9

(Fig. 35, page 37)

TABLE 19

AFTER-EFFECTS OF THYMOL AND CHENOPODIUM*

Symptom	Thymol				Oil of Chenopodium			
1. Dizziness	Frequently noted				More common			
2. Muscular inco-ordination	Noted				More marked			
3. Inability to rise	Noted				Much more frequent			
4. Semi-comatose state (further stage of 2 and 3)	Not noted				Only rarely noted			
5. Burning in stomach	Much more marked				Noted			
6. Headache	More marked				Noted			
7. Tingling of the hands and feet	None				Noted			
8. Vomiting	Dose Gr.	Cases Treated	Cases Vomited	Per Cent Vomited	Dose mils	Cases Treated	Cases Vomited	Per Cent Vomited
	40	65	4	6.2	0.75	10	0	0.0
	60	10	0	0.0	1.5	49	6	12.2
	90	19	3	15.8	3.0	20	3	15.0
	120	19	11	57.9				
	180	10	5	50.0				
	Total	123	23	18.7**	Total	79	9	11.4**

(Concluded next page)

TABLE 19 (concluded)

Symptom	Thymol							Oil of Chenopodium						
9. Albuminuria	Dose Gr.	Examined	Positive	Per Cent Positive	Origin			Dose mils	Examined	Positive	Per Cent Positive	Origin		
					Renal	Gonorrheal	Not Diagnosed					Renal	Gonorrheal	Not Diagnosed
	40	50	6	12.0	2	..	4	1.5	52	7	13.5	..	..	7
								3.0	39	8	20.5	1	4	3
10. Deafness.....	Not Noted							Dose mils	Total Number Treatments		Cases of Deafness			
											Number		Per Cent	
								1.5	000		0		0.0	
								3.0	446		5		1.1	
11. Deaths	None							Two, after two treatments of 3 mils administered with only a four-day interval						

* Figures cover 123 cases treated with thymol in doses ranging from 40 to 180 grains, and 79 cases treated with oil of chenopodium in doses ranging from 0.75 to 3.0 mils.

** The excess of total cases with vomiting after thymol as compared to those treated with chenopodium may be attributed mainly to the administration to twenty-nine patients, in the case of thymol, of doses that exceeded the limit of tolerance.

(Figs. 36, 37, 38, and 39, pages 38 to 41)

TABLE 20

EXPERIMENTS WITH VARIOUS PURGES IN CHENOPODIUM TREATMENT

Drug and Dose	Cases	Worms Removed			Cases Cured by Trial Treatment	
		Entire Treatment	Trial Treatment			
			No.	P.C.	No.	P.C.*
Compound mixture of senna, 2 ounces	6	29	22	75.9	3	50.0
Castor oil, 1½ ounces	9	97	79	81.4	4	44.4
Magnesium sulphate, 1 ounce	10	107	71	66.4	6	60.0
Calomel, 4 grains, and magnesium sulphate, 1 ounce	6	62	50	80.6	3	50.0

*See Table 12.

(Fig. 40, page 42)

TABLE 21
RESULTS OBTAINED BY VARYING DIET AND OMITTING INITIAL PURGE IN TREATING HOOKWORM DISEASE WITH CHENOPODIUM

Diet	With Purge				Without Purge			
	Cases	Worms Removed			Cases	Worms Removed		
		Entire Treatment	Trial Treatment			Entire Treatment	Trial Treatment	
			No.	P.C.			No.	P.C.
Diet 1: Full diet all through the treatment	5	220	98	44.5	5	42	24	57.1
Diet 2: Full diet all the day previous to treatment, but milk on the morning of the treatment	4	97	86	88.7	4	64	56	87.5
Diet 3: Rice gruel (kunji) on the afternoon previous to treatment, but milk on the morning of treatment	4	50	46	92.0	5	46	44	95.7
Diet 4: Only milk during the day previous to treatment, and only milk on the morning of treatment	12	202	159	78.7	14	616	347	56.3

(Fig. 41, page 42)

TABLE 22

RESULTS OF EXAMINATIONS FOR HOOKWORM DISEASE AT PORT SWETTENHAM

	Persons Examined	Persons Positive	Per Cent Positive
Total	**2,262**	**2,188**	**96.7**
Men	1,736	1,696	97.7
Women	384	371	96.6
Children 12 years and under	142	121	85.2

(Fig. 48, page 47)

TABLE 23

HOOKWORM INFECTION RATES, BY AGE GROUPS, FOR CHILDREN LESS THAN TWELVE YEARS OLD. MISCROSCOPIC EXAMINATIONS AT PORT SWETTENHAM

Age Group	Examined	Positive	Per Cent Positive
All ages less than twelve	**142**	**121**	**85.2**
1 year or less	3	0	0.0
1 and 2 years	6	4	66.7
3–4 "	21	16	76.2
5–7 "	36	31	86.1
8–10 "	44	40	90.9
11–12 "	32	30	93.8

(Fig. 49, page 48)

TABLE 24

VULNERABILITY OF WORMS TO VERMICIDE, BY SPECIES AND SEX

BASED ON SAME DATA AS TABLE 24A. PERCENTAGE REMOVED BY FIRST AND SUBSEQUENT TREATMENTS, ASSUMING AS 100% THE TOTAL NUMBER OF WORMS ORIGINALLY HARBORED, OF ALL SPECIES AND SEXES, IRRESPECTIVE OF NUMBER HARBORED AT THE TIME OF TREATMENT

Worms Removed	Total Worms	Species				Necators				Ancylostomes				Total Worms by Sex			
		Necators		Ancylostomes		Male		Female		Male		Female		Male		Female	
		No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.	No.	P.C.
Entire Treatment	**4,553**	**3,998**	**100.0**	**555**	**100.0**	**2,017**	**100.0**	**1,981**	**100.0**	**242**	**100.0**	**313**	**100.0**	**2,259**	**100.0**	**2,294**	**100.0**
1st treatment	4,296	3,871	96.8	425	76.6	1,976	98.0	1,895	95.7	223	92.1	202	64.5	2,199	97.3	2,097	91.4
2d "	217	108	2.7	109	19.6	38	1.9	70	3.5	16	6.6	93	29.7	54	2.4	163	7.1
3d "	39	19	0.5	20	3.6	3	0.1	16	0.8	3	1.2	17	5.4	6	0.3	33	1.4
4th "	1	0	...	1	0.2	...	...	...	...	...	...	1	0.3	...	...	1	*0.1

* Less than one-tenth of one per cent.

(Fig. 50, page 48)

TABLE 24A

VULNERABILITY OF WORMS TO VERMICIDE, BY SPECIES AND SEX

PERCENTAGE REMOVED BY FIRST AND SUBSEQUENT TREATMENTS, ASSUMING AS 100% THE TOTAL NUMBER OF WORMS HARBORED, OF EACH SPECIES AND SEX, AT THE TIME OF EACH TREATMENT

Treatments	Worms Removed					Necators					Ancylostomes				
	Total	Necators		Ancylostomes		Total	Males		Females		Total	Males		Females	
All Treatments	**4,553**	**3,998**	**87.8**	**555**	**12.2**	**3,998**	**2,015**	**50.4**	**1,983**	**49.6**	**555**	**242**	**43.6**	**313**	**56.4**
First Treatment	4,296	3,871	90.1	425	9.9	3,871	1,974	51.0	1,897	49.0	425	223	52.5	202	47.5
Second "	217	108	49.8	109	50.2	108	38	35.2	70	64.8	109	16	14.7	93	85.3
Third "	39	19	48.7	20	51.3	19	3	15.8	16	84.2	20	3	15.0	17	85.0
Fourth "	1	...	...	1	100.0	...	...	...	...	...	1	...	...	1	100.0

TABLE 25

EFFECT ON NECATORS AND ANCYLOSTOMES OF VARYING DOSAGES OF CHENOPODIUM

SINGLE TRIAL TREATMENT

Species and Sex of Worm	Percentage Removed of Total Worms Present		Difference between Effect of Higher and Lower Dose
	2 mils and over	1.5 mils and under	
Necators, male	99.6	97.4	2.2
Necators, female	98.4	94.9	3.5
Ancylostomes, male	95.9	90.5	5.4
Ancylostomes, female	78.3	58.8	19.5
Percentage difference between the most and the least resistant worm classes	21.3	38.6	

(Fig. 51, page 49)

TABLE 26

EFFECT ON NECATORS AND ANCYLOSTOMES OF VARYING DOSAGES OF THYMOL

SINGLE TRIAL TREATMENT

Species and Sex of Worm	Percentage Removed of Total Worms Present		Difference between Effect of Higher and Lower Dose
	90 gr.	60 gr. and under	
Necators, male	99.0	80.0	19.0
Necators, female	97.4	73.7	23.7
Ancylostomes, male	92.6	30.9	61.7
Ancylostomes, female	94.3	37.9	56.4
Percentage difference between the most and the least resistant worm classes	4.7	42.1	

(Fig. 51, page 49)

TABLE 27

DIFFICULTY OF EXPELLING WORMS WHEN NUMBER HARBORED IS SMALL

PERCENTAGE REMOVED BY FIRST TREATMENT, WHEN NUMBER OF WORMS HARBORED IS LARGE, COMPARED WITH PERCENTAGE REMOVED BY SECOND TREATMENT, WHEN NUMBER HARBORED IS CORRESPONDINGLY SMALLER. CHENOPODIUM AND VARIOUS DOSAGES OF THYMOL EMPLOYED

Drug and Dose	First Treatment			Second Treatment		
	Total Worms Present	Worms Removed	Percentage Removed	Total Worms Left After First Treatment	Worms Removed	Percentage Removed
All drugs and all dosages employed	**5,636**	**4,639**	**82.3**	**997**	**372**	**37.3**
Oil of chenopodium, 0.5 mils, three times	2,266	2,168	95.7	98	76	77.6
Thymol, 20 grains twice in capsules	2,033	1,586	78.0	447	100	22.4
Thymol, 20 grains twice in capsules and sugar of milk	887	548	61.8	339	156	46.0
Thymol, 20 grains twice in powder	67	53	79.1	14	1	7.1
Thymol, 20 grains twice in powder, with sugar of milk	383	284	74.2	99	39	39.4

(Fig. 52, page 50)

TABLE 28

AVERAGE HEMOGLOBIN AND AVERAGE NUMBER OF HOOKWORMS HARBORED BY EIGHTY-EIGHT CHINESE TREATED AT SINGAPORE, BY SEX AND AGE

CASES WITH NO PREVIOUS RESIDENCE OTHER THAN CHINA COMPARED WITH CASES HAVING OTHER PREVIOUS RESIDENCE

Sex or Age Group	Cases	Percentage of Hookworm Infection	Average Hemoglobin	Cases with No Evidence of Former Residence Other Than China			Cases with Evidence of Former Residence Other Than China		
				Number	Average Hemoglobin	Average Hookworms per Case	Number	Average Hemoglobin	Average Hookworms per Case
Total	**88**	**88.6**	**74.9**	**60**	**75.1**	**31.5**	**28**	**74.5**	**20.0**
Men	62	90.3	77.5	50	77.8	32.3	12	76.3	23.7
Women	20	85.0	65.5	7	55.6	34.9	13	70.8	19.0
Children	6	83.3	79.5	3	75.7	10.3	3	83.3	10.0

(Fig. 53, page 52)

TABLE 29

RESULTS OF EXAMINATION FOR HOOKWORM DISEASE IN FIJI ISLANDS

Race, Sex, or Age Group	Examined	Infected	Per Cent Infected
Total	**190**	**183**	**96.3**
Indians:			
Men	131	131	....
Women	11	10	....
Children	2	2	....
Fijians:			
Men	20	20	....
Women	4	4	....
Children	9	9	....
Half-castes:			
Adults	1	0	....
Children	7	5	....
European Children	5	2	....

TABLE 30

HOOKWORM-SPECIES FORMULA ACCORDING TO RACE, OCCUPATION, ENVIRONMENT, ETC.

Race	No. of Persons	Special Considerations, such as Condition, Occupation, Environment, etc.	Native Place	Total Hookworms Removed	Average No. of Hookworms Per Person	No. of Ancylostomes	Average No. of Ancylostomes Per Person	Ancylostome Index, or Proportion of Ancylostomes to Total Hookworms Harbored
Malay	38	School boys, Kampong Bharu	Malaya, K.L.	2,262	59.5	5	0.13	0.2
Malay	39	School boys, Ulu Gombak	Malaya, Ulu Gombak	1,559	40.0	13	0.33	0.8
Malay	16	Malays, 13 males and 3 females born in Federated Malay States	Malaya	1,138	71.1	10	0.63	0.9
Malay	12	Malays born in Java, location unknown	Java	1,757	146.4	46	3.83	2.6
Malay	28	Malays born in Sumatra	Sumatra	2,746	98.1	58	2.07	2.1
Malay	12	Malays born in Sumatra, Jail Series, Batavia	Sumatra	919	76.6	7	0.58	0.8
Malay	83	Malays, Batavia Kampongs	West Java	2,935	35.4	26	0.31	0.9
Malay	25	Sudanese, Preanger, Kampong Endil	Preanger, Java	1,275	51.0	2	0.08	0.2
Malay	25	Sudanese, Preanger, Tjimatjan	Preanger, Java	150	6.0	0	0.00	0.0
Chinese	2	Straits-born Chinese	Malacca, S.S.	72	36.0	0	0.00	0.0
Chinese	1	Batavia-born Chinese	Batavia	123	123.0	1	1.00	0.8
Malay	4	Celebes, Jail Series, Batavia	Celebes	523	130.8	0	0.00	0.0
Tamils	?	From Madras, India. Worms Recovered from Treatments	South India	10,455	?	312	?	3.0
Tamils	34	Treatments, Tamils recently from Madras	South India	4,363	128.3	89	2.62	2.0
Malabaris	25	Patients, Hospital No.1, Fed. Malay States	South India	3,491	139.6	30	1.20	0.9
Tamils	35	Road Coolies, Federated Malay States	South India	2,870	82.0	59	1.69	2.1
Sikhs and Pathans	13	Police, Federated Malay States	North India	124	9.5	86	6.62	69.4

TABLE 30 (concluded)

Race	No. of Persons	Special Considerations, such as Condition, Occupation, Environment, etc.	Native Place	Total Hookworms Removed	Average No. of Hookworms Per Person	No. of Ancylostomes	Average No. of Ancylostomes Per Person	Ancylostome Index, or Proportion of Ancylostomes to Total Hookworms Harbored
Chinese	5	Fatal cases of severe hookworm disease (post mortem records)	South China	4,387	877.4	3,779	755.80	86.1
Chinese	46	Newcomers from China, "Sinkehs"	South China	1,241	27.0	420	9.13	33.8
Chinese	79	Patients, Hospital No. 1, F.M.S.	South China	5,191	65.7	1,994	25.24	38.4
Chinese	13	Estate Coolies, Sumatra, Jail Batavia	South China	838	64.5	255	19.62	30.4
Malays	2	Sumatra Malays, probably infected from Chinese sources	Sumatra	38	19.0	25	12.50	65.8
Tamils	57	Night-soil Coolies, F.M.S., infected from Chinese	South India	7,259	127.4	806	14.14	11.1
Tamils	118	Patients, District Hospital, infected from Chinese	South India	12,806	108.5	658	5.58	5.1
Javanese	50	Java, Gebongelir, Kampongs	Mid-Java	2,339	46.8	308	6.16	13.2
Javanese	24	Java, Kalimaro, Kampongs	Mid-Java	5,140	214.2	322	13.42	6.3
Javanese	25	Java, Kebasekan, Kampongs	Mid-Java	4,082	163.3	219	8.76	5.4
Javanese	28	Java, Krakal-Karangsari, Kampongs	Mid-Java	10,861	387.9	770	27.50	7.1
Javanese	9	Prisoners, Batavia Jail	Mid- and East Java	755	83.9	57	6.33	7.5
Madurese	16	Prisoners, Batavia Jail	Madura	1,263	78.9	173	10.81	13.7
Balinese	5	Prisoners, Batavia Jail	Bali	348	69.6	14	2.80	4.0
Timorese	4	Prisoners, Batavia Jail	Timor	100	25.0	61	15.25	61.0
Lombokans	4	Prisoners, Batavia Jail	Lombok	479	119.8	16	4.00	3.3
Chinese	1	Chinese born in Mid-Java, Semarang	Mid-Java	57	57.0	11	11.00	19.3

(Fig. 54, page 54)

TABLE 31

RESULTS OF FECAL EXAMINATIONS FOR HOOKWORM DISEASE AND BLOOD EXAMINATIONS FOR MALARIA, DISTRICT HOSPITAL AT KUALA LUMPUR

CLASSIFICATION BY RACES

Race	Hookworm Ova			Malaria Parasites		
	No. Examined	No. Positive	P.C. Positive	No. Examined	No. Positive	P.C. Positive
All Races	**524**	**399**	**76.1**	**588**	**208**	**35.4**
Chinese	323	246	76.2	363	90	24.8
Tamils	173	130	75.1	191	105	55.0
Bengalese	24	20	83.3	30	11	36.7
Singalese	3	3	100.0	3	1	33.3
Japanese	1	...	0.0	1	1	100.0

(Fig. 57, page 65)

TABLE 32

RATES OF MALARIA AND HOOKWORM INFECTION AMONG CHINESE, TAMIL, AND BENGALESE PATIENTS. FIVE HUNDRED TWENTY-TWO CASES AT DISTRICT HOSPITAL, KUALA LUMPUR

	All Races		Chinese		Tamils		Bengalese	
	No. of Cases	P. C.	No. of Cases	P. C.	No. of Cases	P. C.	No. of Cases	P. C.
All Races; positive and negative	**522**	....	**328**	....	**170**	....	**24**	....
Positive to Hookworm; Total	395	75.7	249	75.9	126	74.1	20	83.3
Positive to Hookworm; Positive to Malaria	133	25.5	58	17.7	68	40.1	7	29.1
Positive to Hookworm; Negative to Malaria	262	50.2	191	58.2	58	34.1	13	54.2
Negative to Hookworm; Total	127	24.3	79	24.1	44	25.9	4	16.7
Negative to Hookworm; Positive to Malaria	51	9.8	23	7.0	27	15.9	1	4.2
Negative to Hookworm; Negative to Malaria	76	14.6	56	17.1	17	10.0	3	12.5
Positive to Malaria; Total	184	35.2	81	24.7	95	55.9	8	33.3
Positive to Malaria; Positive to Hookworm	133	25.5	58	17.7	68	40.0	7	29.1
Positive to Malaria; Negative to Hookworm	51	9.8	23	7.0	27	15.9	1	4.2
Negative to Malaria; Total	338	64.8	247	75.3	75	44.1	16	66.7
Negative to Malaria; Positive to Hookworm	262	50.2	191	58.2	58	34.1	13	54.2
Negative to Malaria; Negative to Hookworm	76	14.6	56	17.1	17	10.0	3	12.5

(Fig. 58, page 66)

TABLE 33

CORRELATION BETWEEN INTENSITY OF ENLARGED SPLEENS AND PREVIOUS RESIDENCE

SPLEEN EXAMINATIONS OF COOLIES ENTERING AT PORT SWETTENHAM

Spleen Condition	All Previous Residences	Previous Residence		
		Federated Malay States	Other Countries	India Only
Total Cases	**2,261**	**437**	**98**	**1,726**
Enlarged spleens	130	59	11	60
Percentage of enlarged spleens	5.7	13.5	11.2	3.5
Enlarged spleens classified:				
a. Palpable	69	27	7	35
b. One finger's breadth	28	12	1	15
c. Two fingers' "	23	15	1	7
d. Three fingers' "	6	3	0	3
e. Hand's breadth	2	1	1	0
f. Below the umbilicus	2	1	1	0

(Fig. 59, page 66)

TABLE 34

CORRELATION BETWEEN MALARIA PLASMODIA AND FORMER RESIDENCE, SPLENIC CONDITION, AND AGE OF PATIENT

BLOOD EXAMINATIONS OF COOLIES ENTERING AT PORT SWETTENHAM, 1915–1916

Findings in 1915

Previous Residence, Splenic Condition, and Age	Number Examined	Percentage Positive for Plasmodia
Total	**336**	**6.8**
Federated Malay States	124	9.7
India only	189	5.2
Other countries: Total	23	4.3
(a) Straits Settlements	4	25.0
(b) Ceylon	16	0.0
(c) Natal	2	0.0
(d) Rangoon	1	0.0
Spleen enlarged	100	14.0
Spleen not enlarged	236	3.8
Children 12 years and under	110	1.8
Adults	226	9.2

(Concluded next page)

(Fig. 60, page 67)

TABLE 34 (concluded)
Findings in 1916

Previous Residence, Splenic Condition, and Age	Number Examined	Percentage Positive for Plasmodia
Total	**250**	**4.8**
Children 12 years and under	78	2.6
Adults	172	5.8
Former residence India only	204	3.4
Former residence other than India	46	10.9
(a) Federated Malay States	40	12.5
(b) Ceylon	3	0.0
(c) Singapore	1	0.0
(d) Malacca	1	0.0
(e) Johore	1	0.0

TABLE 35

HEMOGLOBIN OF COOLIES WHO HAD PREVIOUSLY LEFT INDIA COMPARED WITH HEMOGLOBIN OF THOSE WHO HAD NOT

TWENTY-TWO HUNDRED TWENTY-FIVE COOLIES EXAMINED FOR MALARIA AT PORT SWETTENHAM

Hemoglobin Rate	Coolies With or Without Record of Previous Emigration from India	Coolies Without Record of Previous Emigration		Coolies With Record of Previous Emigration	
		No.	Percentage of Total	No.	Percentage of Total
Total	**2,225**	**1,690**	**76.0**	**535**	**24.0**
100–110	32	23	71.9	9	28.1
90–99	213	159	74.6	54	25.4
80–89	731	571	78.1	160	21.9
70–79	692	535	77.3	157	22.7
60–69	165	120	72.7	45	27.3
50–59	213	159	74.6	54	25.4
40–49	112	84	75.0	28	25.0
30–39	44	27	61.4	17	38.6
20–29	14	9	64.3	5	35.7
10–19	5	2	40.0	3	60.0
0–9	4	1	25.0	3	75.0

TABLE 36

CORRELATION BETWEEN HEMOGLOBIN RATE AND SIZE OF ENLARGED SPLEEN

TWENTY-TWO HUNDRED TWENTY-FIVE COOLIES EXAMINED FOR MALARIA ENTERING AT PORT SWETTENHAM

Hemoglobin Rate	Coolies Examined	Coolies with Enlarged Spleens		Classification of Enlarged Spleens					
		No.	Percentage of Total	Palpable	1 fb.	2 fb.	3 fb.	Hand's Breadth	Below the Umbilicus
Totals	**2,225**	**130**	**5.8**	**69**	**28**	**23**	**6**	**2**	**2**
100–110	32	2	6.3	1	1	..	..	..	..
90–99	213	9	4.2	7	1	1	..	..	..
80–89	731	21	2.9	13	6	1	..	1	..
70–79	692	32	4.6	20	7	4	..	1	..
60–69	165	11	6.7	5	2	3	1	..	..
50–59	213	19	8.9	7	3	6	2	..	1
40–49	112	19	17.0	7	5	6	1	..	..
30–39	44	11	25.0	5	2	1	2	..	1
20–29	14	2	14.3	1	..	1	..	..	..
10–19	5	2	40.0	1	1	..	..	..	..
0–9	4	2	50.0	2	..	..	..	..	..

(Fig. 61, page 68)

TABLE 37

GAIN OR LOSS IN HEMOGLOBIN AFTER RESIDENCE ON ESTATES

RESULTS OF RE-EXAMINATION, ON ESTATES, OF TWO HUNDRED THIRTY-FOUR COOLIES FOUND FREE OF MALARIA BUT INFECTED WITH HOOKWORM DISEASE ON ARRIVAL AT PORT SWETTENHAM

Estate	Number of Coolies	Cases with Signs of Malaria after Residence on Estates						Cases with No Signs of Malaria after Residence on Estates					
		Treated at Port Swettenham			Not Treated at Port Swettenham			Treated at Port Swettenham			Not Treated at Port Swettenham		
		No. of Coolies	Total Change in Hemoglobin	Average Change in Hemoglobin	No. of Coolies	Total Change in Hemoglobin	Average Change in Hemoglobin	No. of Coolies	Total Change in Hemoglobin	Average Change in Hemoglobin	No. of Coolies	Total Change in Hemoglobin	Average Change in Hemoglobin
Total	**234**	**28**	**−159**	**−5.7**	**44**	**−457**	**−10.4**	**41**	**+624**	**+15.2**	**121**	**+730**	**+6.0**
In flat country:—													
Estate No. 1	10	..	...	...	1	+10	+10.0	4	+55	+13.8	5	+45	+9.0
" " 2	20	..	...	...	..	...	...	2	+25	+12.5	18	+183	+10.2
" " 3	20	1	+28	+28.0	6	−90	−15.0	2	+5	+2.5	11	+146	+13.3
" " 4	33	..	...	...	..	...	...	7	+230	+32.9	26	+35	+1.4
" " 5	21	1	0	0.0	2	+5	+2.5	2	+50	+25.0	16	+15	+0.9
Undulating and hilly country:—													
Estate No. 6	6	..	...	...	1	+5	+5.0	2	+20	+10.0	3	+45	+15.0
" " 7	23	5	+11	+2.2	1	0	0.0	6	+99	+16.5	11	+74	+6.7
" " 8	13	1	+16	+16.0	4	−2	−0.5	..	...	...	8	+105	+13.1
" " 9	11	2	−8	−4.0	3	+25	+8.3	2	+3	+1.5	4	−14	−3.5
" " 10	12	1	−5	−5.0	2	+5	+2.5	3	+5	+1.7	6	+30	+5.0
" " 11	26	6	−41	−6.8	6	−67	−11.2	8	+104	+13.0	6	+36	+6.0
" " 12	19	3	+68	+22.6	8	−92	−11.5	1	+3	+3.0	7	+30	+4.3
" " 13	8	5	−125	−25.0	1	−40	−40.0	2	+25	+12.5	..	...	...
" " 14	12	3	−103	−34.3	9	−216	−24.0	..	...	...	..	...	...

(Fig. 62, page 70)

TABLE 38

GAIN OR LOSS IN HEMOGLOBIN AFTER RESIDENCE ON ESTATES

RESULTS OF RE-EXAMINATION, ON ESTATES, OF NINETEEN COOLIES FOUND INFECTED WITH MALARIA ON ARRIVAL AT PORT SWETTENHAM

Estate	Number of Coolies	Effect of Subsequent Malaria						Effect of Hookworm Treatment					
		Cases with Evidence of Malaria at Port Swettenham as well as on Estate			Cases without Evidence of Malaria on Estate			Cases Treated at Port Swettenham			Cases Not Treated at Port Swettenham		
		No. of Coolies	Change in Hemoglobin		No. of Coolies	Change in Hemoglobin		No. of Coolies	Change in Hemoglobin		No. of Coolies	Change in Hemoglobin	
			Total Change	Average Change		Total Change	Average Change		Total Change	Average Change		Total Change	Average Change
Total	**19**	**12**	**+127**	**+10.6**	**7**	**+116**	**+16.6**	**5**	**+79**	**+15.8**	**14**	**+164**	**+11.7**
On flat country:—													
Estate No. 1.....	3	1	+15	+15.0	2	+40	+20	..	..	...	3	+55	+18.3
" " 3.....	1	1	−30	−30.0	..	...	...	1	−30	−30.0	..	...	...
" " 4.....	1	..	...	...	1	0	0	..	..	...	1	0	0
Undulating and hilly country:—													
Estate No. 7.....	1	1	+31	+31.0	..	...	...	..	..	...	1	+31	+31
" " 8.....	1	..	...	...	1	−8	−8	..	..	...	1	−8	−8
" " 9.....	1	1	+25	+25.0	..	...	...	..	..	...	1	+25	+25
" " 10.....	2	2	+35	+17.5	..	...	...	..	..	...	2	+35	+17.5
" " 11.....	4	1	−7	−7.0	3	+84	+28	2	+79	+39.5	2	−2	−1
" " 12.....	2	2	+23	+11.5	..	...	...	1	+15	+15.0	1	+8	+8
" " 13.....	1	1	+15	+15.0	..	...	...	1	+15	+15.0	..	...	...
" " 14.....	2	2	+20	+10.0	..	...	...	..	..	...	2	+20	+10

(Fig. 62, page 70)

TABLE 39

GAIN OR LOSS IN HEMOGLOBIN AFTER RESIDENCE ON ESTATES

RESULTS OF RE-EXAMINATION, ON ESTATES, OF TWELVE COOLIES FOUND FREE OF MALARIA AND HOOKWORM DISEASE ON ARRIVAL AT PORT SWETTENHAM

Estate	No. of Coolies	Cases with Evidence of Malaria Subsequent to Arrival			Cases without Evidence of Malaria		
		No. of Coolies	Change in Hemoglobin		No. of Coolies	Change in Hemoglobin	
			Total Change	Average Change		Total Change	Average Change
Total	**12**	**7**	**−110**	**−15.7**	**5**	**−8**	**−1.6**
In flat country:—							
Estate No. 3	8	3	−87	−29.0	5	−8	−1.6
In hilly, undulating country:—							
Estate No. 8	1	1	−8	−8.0	..	..	..
" " 12	1	1	−15	−15.0	..	..	..
" " 13	2	2	0	0.0	..	..	..

(Fig. 65, page 73)

TABLE 40

CORRESPONDENCE BETWEEN MALARIA AND GAIN OR LOSS IN HEMOGLOBIN AFTER RESIDENCE ON ESTATES

RESULTS OF RE-EXAMINATION, ON ESTATES, OF 267 COOLIES PREVIOUSLY EXAMINED AT PORT SWETTENHAM, UPON ENTRY INTO FEDERATED MALAY STATES

Estate	Total Cases	Average Change in Hemoglobin		Cases with Evidence of Malaria	Evidence of Malaria in Each Group
With gain over 10%					
Estate No. 1	13	+12.7	+11.4	5	8 in 39 cases or 20.5%
" " 6	6	+11.7		2	
" " 2	20	+10.4		1	
With gain of 5 to 10%					
Estate No. 7	24	+9.0	+7.5	7	25 in 87 cases or 28.7%
" " 4	34	+7.8		7	
" " 8	15	+6.9		6	
" " 10	14	+5.0		5	
With gain of 0 to 5%					
Estate No. 5	21	+3.3	+1.6	13	43 in 92 cases or 46.7%
" " 9	12	+2.8		6	
" " 3	29	+1.2		11	
" " 11	30	+0.3		13	
With loss of 0 to 10%					
Estate No. 12	24	−2.1		16	16 in 24 cases or 66.7%
With loss of 10 to 20%					
Estate No. 13	11	−11.4		9	9 in 11 cases or 81.8%
With loss over 20%					
Estate No. 14	14	−21.3		14	14 in 14 cases or 100%

(Fig. 66, page 74)

TABLE 41

RELATIONSHIP BETWEEN SPLENIC CONDITION AND NUMBER OF HOOKWORMS HARBORED

EIGHTY-THREE PERSONS TREATED FOR HOOKWORM IN KAMPONGS OF JAVA

Kampong	Spleen Negative		Spleen Palpable		Spleen Enlarged	
	No. of Cases	No. of Worms	No. of Cases	No. of Worms	No. of Cases	No. of Worms
Total	**44**	**1,391**	**10**	**495**	**29**	**1,683**
Jaagpad	0	0	1	10	14	506
Djmbatan	5	332	7	337	9	371
Sawah Besar	19	187	0	0	6	806
Kramat	20	872	2	148	0	0
Average number of worms		31.6		49.5		58.0
				55.8		

(Fig. 71, page 77)

TABLE 42

CORRELATION BETWEEN PRESENCE OF MALARIA AND NUMBER OF HOOKWORMS HARBORED

EIGHTY-EIGHT CASES IN JAVA JAIL

Groups	Cases	Evidence of Malaria	Average Hemoglobin	Average No. of Hookworms	Average Length of Time in Jail, Months
Group I	6	Spleen palpable; plasmodia present	68.2	77.3	40.0
Group II	1	Spleen enlarged; plasmodia present	48.0	81.0	84.0
Group III	17	Spleen palpable; plasmodia absent	63.2	106.0	25.2
Group IV	3	Spleen enlarged; plasmodia absent	41.3	200.0	25.3
Group V	13	Spleen negative; plasmodia present	78.5	76.1	19.5
Group VI	48	Spleen negative; plasmodia absent	81.2	54.8	25.9
Malarious group (I–V)			66.9	98.4	
Non-malarious group (VI)			81.2	54.8	

(Fig. 72, page 78)

TABLE 43

RELATIONSHIP BETWEEN NUMBER OF HOOKWORMS HARBORED AND PRESENCE OR ABSENCE OF MALARIA PLASMODIA IN BLOOD

Based on Table 42, Covering Analysis of 88 Cases in Java Jail

	Plasmodia absent; spleen negative	Plasmodia present; spleen negative	Plasmodia absent; irrespective of spleen	Plasmodia present; irrespective of spleen	Spleen negative; irrespective of plasmodia	Spleen palpable; irrespective of plasmodia	Spleen enlarged; irrespective of plasmodia
Cases	48	13	68	20	61	23	4
Average hemoglobin	81.2	78.5	74.9	73.8	80.6	64.5	43.0
Average number of worms	54.8	76.1	74.0	76.7	59.2	98.5	170.5
Period of jail residence	24 to 35 months	12 to 23 months	24 to35 months	24 to 35 months	24 to 35 months	24 to 35 months	35 to 47 months

(Fig. 73, page 79)

TABLE 44

CORRELATION BETWEEN SPLENIC CONDITION AND NUMBER OF HOOKWORMS HARBORED

One Hundred Six Cases in Java Jail

	Spleen Negative	Spleen Palpable	Spleen Enlarged
Cases	63	29	14
Hemoglobin percentage	79.8	63.1	47.2
Hookworms (average number per case)	57.9	98.5	120.4
Length of time in prison (average number of months)	24.3	26.5	32.9

(Fig. 74, page 79)

TABLE 45

HEMOGLOBIN RATE AND DEGREE OF SPLENIC ENLARGEMENT IN RELATION TO LENGTH OF JAIL RESIDENCE

One Hundred Fifteen Prisoners in Treatment Squads in Java Jail

Condition of Spleen	Duration of Stay			
	1 to 3 Months		61 to 72 Months	
	Cases	Average Hemoglobin	Cases	Average Hemoglobin
All conditions	**92**	**83.5**	**23**	**77.9**
Negative	48	85.2	9	82.0
Palpable	31	83.4	6	77.8
One finger's breadth	5	80.6	3	73.1
Two fingers' breadth	7	76.0	2	72.5
Three fingers' breadth	1	75.0	3	74.3

(Fig. 75, page 80)

TABLE 46

SPLENIC ENLARGEMENT IN RELATION TO LENGTH OF JAIL RESIDENCE

FIVE HUNDRED NINETY-FOUR CASES IN JAVA JAIL

Length of Jail Residence	Cases with Enlarged Spleens (Per Cent of Total Cases Examined)	Number of Cases
All periods	**62.5%**	**594**
9 days and under	36.0%	25
1 to 3 months	47.8%	92
4 " 6 "	69.0%	42
7 " 9 "	55.0%	40
10 " 12 "	64.8%	57
13 " 24 "	66.9%	106
25 " 36 "	79.3%	116
37 " 48 "	69.7%	43
49 " 60 "	71.7%	28
61 " 72 "	60.8%	23
73 months and over	90.9%	22

(Fig. 76, page 80)

TABLE 47

HOOKWORM INFECTION AND MALARIA AS ANEMIA-PRODUCING FACTORS IN DESSAS OF GEBONGELIR, JAVA

By Sex and Age Groups

	Men	Women	Boys	Girls
Calculated normal hemoglobin	95	86	85	85
Actual hemoglobin average of dessa group	56.1	47.9	56.8	68
Calculated loss	38.9	38.1	28.2	17
Average number of hookworms harbored	80.4	24.2	47.8	11.7
Calculated loss of hemoglobin due to hookworms*	6.9%	2.4%	6.1%	1.5%
Balances due to losses from malaria	32.0	35.7	22.1	15.5

Note: In this table it is assumed that all the worms are causing a measurable amount of anemia.

* For derivation of factors used in calculating this loss (7.8 in the case of boys and girls, and 11.7 in the case of men) see Figs. 81 and 83 and text discussion, pages 87 to 90.

(Fig. 84, page 92)

TABLE 48

AVERAGE HEMOGLOBIN RATES AND AVERAGE NUMBER OF HOOKWORMS HARBORED IN ONE MALARIOUS AND TWO NON-MALARIOUS DESSAS OF JAVA

By Sex and Age Groups

Sex and Age Groups	Severe Malaria		Free from Malaria	
	Gebongelir		Kebasekan and Kalimaro	
	Average Hemoglobin	Average Number of Hookworms Harbored	Average Hemoglobin	Average Number of Hookworms Harbored
Men	56.1	80.4	69.2	303
Women	47.9	24.2	69.7	163.3 (Kebasekan only)
Boys	56.8	47.8	71.5	106
Girls	68.0	11.7	83.0	63.4

Note: This table shows that not only is the more severe anemia in the malarious dessa, but that for some reason there is a decidedly smaller number of worms as well. (Fig. 85, page 93)

TABLE 49

RESPECTIVE LOSSES IN HEMOGLOBIN FROM HARD LABOR AND SUB-NUTRITION, MALARIA, AND HOOKWORM INFECTION

PRISONERS IN BATAVIA JAIL, JAVA

	Number of Hookworms Harbored					
	0	1 to 100	101 to 200	201 to 300	301 to 400	401 and over
Calculated normal hemoglobin	95.0	95.0	95.0	95.0	95.0	95.0
Loss due to hard labor and sub-nutrition, i.e. difference between 85.3 and 77.3=8.0	8.0	8.0	8.0	8.0	8.0	8.0
Balance	87.0	87.0	87.0	87.0	87.0	87.0
Average hemoglobin of men with malaria and free from hookworm=76.5	76.5	76.5	76.5	76.5	76.5	76.5
Loss due to malaria	10.5	10.5	10.5	10.5	10.5	10.5
Balance after deducting losses due to hard labor and sub-nutrition, and to malaria	76.5	76.5	76.5	76.5	76.5	76.5
Average hemoglobin in the worm groups	76.5	75.3	62.7	67.4	50.0	37.5
Calculated loss due to hookworm in each group	0.0	1.2	13.8	9.1	26.5	39.0

(Fig. 86, page 94)

TABLE 50

ESTIMATED LOSS OF HEMOGLOBIN DUE TO HOOKWORM DISEASE AMONG POPULATIONS SUBJECTED TO MALARIA, BY HOOKWORM GROUPS

Based on 818 Cases Treated from Schools, Rubber Estates, Public Works, Quarantine Camps, and Prisons in Federated Malay States

All Cases Irrespective of Age, Sex, Race, and Malaria	Total	Number of Hookworms Harbored								
		0 to 5	6 to 50	51 to 100	101 to 150	151 to 200	201 to 250	251 to 300	301 to 600	Above 600
Number of cases	818	244	351	112	44	18	15	10	17	7
Percentage distribution of cases	100%	29.8	42.9	13.7	5.4	2.2	1.8	1.2	2.1	0.9
Average hemoglobin		82.5	80.5	74.9	74.5	69.8	58.2	59.9	54.7	38.7
Average loss of hemoglobin due to worms		...	2.0	7.6	8.0	12.7	24.3	22.6	27.8	43.8
Total loss of hemoglobin=average loss ×number of cases	3,503.5	...	702.0	851.2	352.0	228.6	364.5	226.0	472.6	306.6

(Fig. 87, page 96)

TABLE 51

LOSS OF HEMOGLOBIN FROM PROLONGED MALARIA INFECTION SUPERIMPOSED UPON HOOKWORM INFECTION

HEMOGLOBIN OF INDENTURED INDIAN COOLIES AT NAUSORI, FIJI ISLANDS, COMPARED WITH FREE JAVANESE FROM THREE KAMPONGS AND BATAVIA JAIL

	Number of Hookworms Harbored		
	1 to 50	51 to 100	101 to 150
Indentured Indian coolies, Nausori*			
Average hemoglobin	85.8%	85.0%	81.8%
Number of cases	31	16	9
Javanese men from three kampongs and from Batavia jail†			
Average hemoglobin	68.9%	68.4%	68.8%
Number of cases	83	20	10
Difference=loss due partly to malaria and partly to jail regimen	16.9%	16.6%	13.0%

* Infected with hookworm but free of malaria.
† Infected with hookworm and severely malarious.

(Fig. 90, page 103)

TABLE 52

CORRELATION BETWEEN NUMBER OF HOOKWORMS HARBORED AND RATE OF HEMOGLOBIN

EXAMINATION OF 131 INDIANS FREE OF MALARIA BUT INFECTED WITH HOOKWORM DISEASE AT NAUSORI AND IN SUVA JAIL, FIJI ISLANDS

Number of Hookworms	Hemoglobin Rate																			Total Cases	Ave. Hgb.
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	
0– 50	5	6	13	3	8	6	4	1	1	1	1	.....	.....	.....	1	.....	.....	.....	.....	.....	50	82.5
51–100	....	6	3	7	3	2	2	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23	85.4
101–150	....	1	1	7	3	3	.....	....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	17	79.7
151–200	1	1	1	1	1	1	.....	....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	7	79.3
201–250	1	1	....	1	1	1	.....	....	.....	.....	1	1	.....	.....	.....	.....	.....	.....	.....	.....	7	75.7
251–300	....	....	1	2	1	1	2	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	79.3
301–350	....	....	....	.....	.....	1	1	....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	65.0
351–400	....	....	1	.....	1	.....	1	....	.....	.....	.....	1	.....	1	.....	.....	.....	.....	.....	.....	5	64.0
401–450	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	35.0
451–500	....	....	....	.....	.....	1	.....	....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	2	50.0
501–550	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	1	35.0
551–600	....	....	....	.....	.....	.....	.....	....	1	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	55.0
601–650	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1	45.0
651–700	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	1	2	15.0
701–750	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—	—
751–800	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	40.0
801–850	....	....	....	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	5.0
1001–1050	....	....	....	.....	.....	.....	.....	....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	55.0
Total cases	**7**	**15**	**20**	**21**	**18**	**16**	**10**	**1**	**3**	**2**	**5**	**3**	**1**	**3**	**2**	**2**	—	—	—	**2**	**131**	**76.8**
Ave Worms	75.3	72.4	69.7	114.5	97.8	139.6	148.3	49.0	249.7	514.5	256.8	418.0	789.0	452.7	83.0	576.5	...	...	...	758.5	154.5	

(Figs. 91 and 92, pages 104 and 105)

TABLE 53

TIME REQUIRED TO RAISE HEMOGLOBIN RATES OF ANEMIC PATIENTS

Difficulty of Restoring Normal Hemoglobin Value in Patients after Treating Them for Malaria and Hookworm Disease. Fifty-eight Cases Treated in Special Ward at Kuala Lumpur Hospital

	Average Hemoglobin on Admission								
	0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90
Average hemoglobin on discharge	38.1%	50.9%	59.5%	64.0%	61.7%	60.8%	78.5%	82.0%	93.0%
Average length of time, in days, required to raise hemoglobin	81.7	63.4	48.2	57.0	53.0	35.4	52.0	22.0	21.0
Number of cases	20	9	9	6	5	5	2	1	1
Range in days	22–228	40–82	21–71	35–83	21–81	23–53	43–61	22	21
Range in increase of hemoglobin during period	5–75%	20–73%	33–75%	42–80%	48–76%	33–83%	75–82%	82%	93%

(Fig. 96, page 113)

TABLE 54

SEVERITY OF ANEMIA IN MEN, WOMEN, AND CHILDREN

COMPARATIVE HEMOGLOBIN RATES OF SEXES IN MALARIOUS AND NON-MALARIOUS DISTRICTS. ONE HUNDRED TEN CASES TREATED IN KAMPONGS OF JAVA

	Particulars	A. Cases with Hemoglobin 60 and Over			B. Cases with Hemoglobin 59 and Under			Ratio of A. to B.		
		Men	Women	Children	Men	Women	Children	Men	Women	Children
Malaria-free	Non-malarious Kampongs (Kalimaro and Kebasekan):									
	No. cases.....	13	11	14	5	4	1	1: 0.38	1:0.36	1:0.07
	Average number of hookworms harbored.....	208.8	95.0	91.8	608.8	201.0	163.0	1: 2.9	1: 2.1	1:1.7
Malarious	Malarious Kampongs (Gebongelir and Endil):									
	No. cases.....	12	5	10	8	21	6	1: 0.67	1: 4.2	1: 0.6
	Average number of hookworms harbored.....	30.6	65.2	36.9	56.6	19.5	56	1: 1.8	1: .30	1: 1.5

(Fig. 97, page 116)

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